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THE VITAL HISTORY OF SAN JUAN PUEBLO*

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PREFACE

ONE aspect of American Indian life which remains relatively unexplored is the nature of the vital or population history. The scarcity of accurate source materials is without doubt the main reason that research along these lines has been limited to the grosser facts. As a consequence of this, a great deal of misinformation is current, particularly concerning the longevity of Indians.

The life pattern of a preliterate people gives rise to population phenomena differing considerably from our own. The relatively small numbers present in even the most populous regions is ample demonstration of this fact. And as this mode of life changes, the factors in opera-

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tion in the process of acculturation must indeed be reflected in the composition of the group itself.

It is to be hoped that intensive studies of the vital histories of particular peoples may prove to be of more than limited significance. The researches of the historian and the anthropologist can be enriched by an understanding of the biological phenomena that have been associated with events and relationships on the social level. The administrator who deals with practical problems in reservation life can observe the effects of the contact of the white man's culture and diseases upon the group, as well as the results of remedial efforts toward the abolishment of dysgenic practices and unfavorable environmental conditions. The collection and correlation of data of this type may give rise to contributions of a theoretical nature which cannot be foreseen at this time.

In this study, attention is first directed to the rate of change in the total numbers of the population present and the composition of these totals. Any changes over a period of time in a population such as this, unaffected by migration, are caused by shifts in the relationship between the number of births and deaths. Only by turning to these two primary factors can the causes underlying these changes be understood. As epidemics raise special problems in themselves, separate treatment is given them. Mortality at particular ages, as well as changes in life expectancy over a period of time, are among the topics that are considered.

For a number of reasons, the San Juan Pueblo is a happy choice for an investigation of this type. The village has played a significant rôle in the early history of the Southwest, and this has served to increase the amount of information available concerning it. The presence of settlements of Spanish-Americans in the immediate vicinity gives us a basis for comparisons with a differing people in a similar environment.

The practice of monogamy, a characteristic of San Juan, permits definite determinations of family composition and a comparison of family groups at different periods of time. Contrary to many Indian groups, the people of San Juan tended to retain family names. Thus it was possible to trace some genealogies back as far as 1800.

The documentary evidence, while not always wholly satisfactory, was of sufficiently good quality to insure the essential validity of the results that have been obtained from it. The more important sources employed are discussed below.

One source of information that has been neglected by historians is the local parish records of the Catholic Church. This church, always

in the vanguard of Spanish exploration, early took its place as the center of social life in the New Mexico settlements. The records kept by the priests of baptisms, marriages, and burials are fairly continuous for the parish of San Juan from 1726 to the present day.

Records of births exist for every year with the exception of the period 1820-22. Small gaps of several months or weeks also occur; the nature of the various omissions and the means that were employed to correct them are discussed in the section on natality. The precise form of the records varied from priest to priest, but the information usually included the date, name, race, place of birth, and the names of the parents. Sometimes the names of the grandparents or notations concerning legitimacy or social status were entered.

The marriage records were quite incomplete, and only indirectly of use in this study. The records of burials were roughly similar in form to those of births. However, as fewer entries were made of burials than of births, greater difficulties were encountered in adjusting for the known omissions.

During the 208 year period under consideration, 32 priests were in charge of the parish; their names and the tenures of each have been included as an appendix. In the short periods between these tenures, no records were kept, which was one of the reasons necessitating adjustment in the figures before they could be used. Occasional inspections by the higher church authorities served as a check on the work of these men.

As a supplement to the church records, additional data on the population of the parish and the pueblo were obtained from four main sources; the Spanish civil authorities, the Franciscan fathers, the United States census, and the United States Office of Indian Affairs. The original records from the first two sources for the years prior to 1790 were not available to us, and we have been dependent upon their quotation from secondary sources. The documents for the period 1790-1821, however, are in the Spanish Archives of New Mexico and photostatic copies of them were generously supplied by the Department of History of the University of New Mexico. In addition to the United States census records, population counts and estimates were often to be found in the reports of the various agents of the Indian Service; annual census figures from the Indian Service for the period 1923-1936 were accessible in manuscript form. The above sources are discussed at greater length in the sections of the paper in which they are employed.

To the extent that the data would allow, comparisons have been made between the pueblo figures and those from the Spanish population included in a section of the parish. It was felt that the latter would serve to a certain extent as a control group and as a means of bringing out the factors inherent in the Indian life. Since the geographical boundaries of the parish have shifted through the years, and because the church records are more complete from some districts than others, a definite area for the study was determined. The designations "pueblo area" and "Spanish area" are used in reference to the two sections of the parish under consideration.

I. INTRODUCTION

The San Juan Pueblo is located in the parish of that name which lies along both banks of the Rio Grande at a distance of twenty-five miles northwest of Santa Fe, New Mexico. The valley is very fertile, and in the immediate region, in addition to the Indian village, are a number of Spanish-American farming settlements. The pueblo, itself, is situated near the east bank of the river, and is largely composed of single-story adobe houses of one or two rooms. In general, the houses are arranged in four rows, separated by two plazas and a roadway.

Together with the Santa Clara, San Ildefonso, Nambe, Pojoaque, Tesuque, and Hano[1] Pueblo Indians, the people of San Juan comprise the Tewa branch of the Tanoan language and are the most northerly of the group.

While mixture with European peoples has been slight, Hrdlička[2] says with regard to physical characteristics: "The Pueblos are not a homogeneous group, but neither are they any more a gathering of readily separable distinct anthropological units. They are an old aggregate of tribes and clans brought more or less together by acculturation and intermixtures" (pp. 457-458). Intermarriage with outsiders has been mainly with the Apaches and the Utes.

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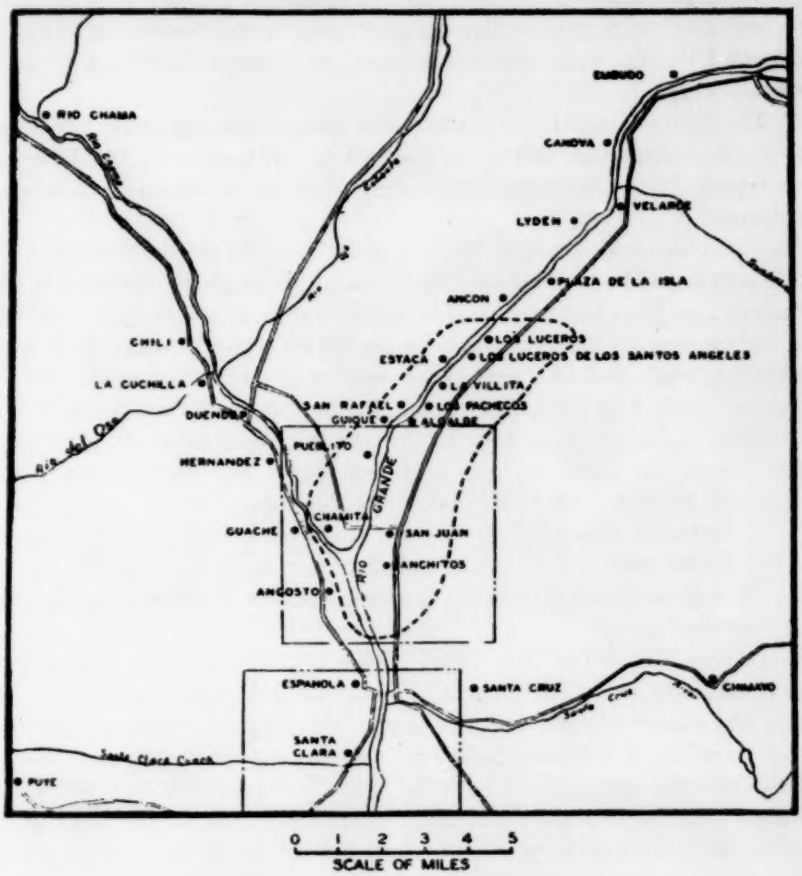
[1] The Pueblo of Hano is located in the Hopi Country of northeastern Arizona and dates from the time of the Pueblo revolt of 1680-1692. Twitchell, R. E. Leading Facts of New Mexican History: Torch Press, *Cedar Rapids, Iowa*, p. 737.

[2] Aleš Hrdlička. The Pueblos. *Amer. Jour. of Phys. Anthropol.*, 20, 1935, p. 235.

SAN JUAN PUEBLO & THE STUDY AREA

—·—·—PUEBLO GRANTS -------STUDY AREA



A brief examination of the written history of San Juan may prove of value as a background upon which to project our study of the population.

White contact was first made with these people when a small body of troops from Coronado's expedition entered the pueblo in 1541 in

search of food. Fray Rodriquez, who visited the pueblo forty years later, describes it as having two or three hundred houses three and four stories high. It is possible that other early explorers reached San Juan, but if so, no clear record of their visits has been found.

The colonization of the territory actually began in 1598, when Oñate left Mexico with an expedition consisting of soldiers, missionaries, and according to one account, a large herd of stock. The village of San Juan became the first Spanish settlement and capital in the Southwest. Oñate extended the existing irrigation system, built houses for his men and erected a church.

The importance of the pueblo soon diminished, however, when in 1610 the capital was shifted to Santa Fe. Although the Franciscans continued their missionary work at San Juan, the number of friars was reduced.

The Indians had originally been quite friendly to the Spanish, but this attitude did not long continue. In 1680 under the leadership of Pope, a San Juan Indian, a combined uprising of all the pueblos resulted in the clearing of the Spanish from the entire region. Reconquest was begun in 1692, and in a few years order was established again. Missionary work had been interrupted by the rebellion but there is no evidence of the length of time the mission had been functioning at San Juan when the parish records begin in 1726. For the next hundred years the territory continued under Spanish rule.

In terms of this study, the severe smallpox epidemic in 1781 is of great significance. It is discussed together with later epidemics in the section on mortality in the pueblo (Section 4.—Mortality: under "Epidemics").

During this period both the pueblos and the Spanish settlements were molested by roving groups of Apaches, Comanches, and Utes. It was the governor's duty to afford protection against these marauders and there are numerous reports of punitive expeditions against them. However, the attempts of both the central government and the local troops failed to subdue them, and control came only in the latter part of the nineteenth century as a result of campaigns by the United States Army.

With the coming of American trade, following the visit of Zebulon Pike to the region in 1806-07, San Juan was recognized as a convenient stopping place on the route that led through Taos to Santa Fe. This trade was restricted by the Spanish, but was welcomed following the revolt by Mexico in 1821. The revolutions of the time had little direct

effect in New Mexico except as they were instrumental in producing a reorganization of both the government and the church.

The territorial and boundary disputes between Mexico and the United States, which had been occurring for some time, finally led to war in 1845. Occupation of New Mexico was accomplished peaceably, following its annexation, but shortly thereafter the Pueblos took part with the Spanish-Americans in a final revolt in which the governor, Charles Bent, was assassinated.

The first United States Indian Agent, James S. Calhoun, was appointed in 1849. Although he was faced with many difficult problems, Calhoun soon realized the desirability of fair and honest dealing with the Pueblos, and made frequent appeals to Congress on their behalf.

From this time on, the history of San Juan is intermingled with that of the Indian Service policy of the United States Government, which has never been adequately recounted, especially in regard to the pueblos. To summarize chronologically the significant points: (1) The pueblos were recognized essentially as reservations with a distinguishing feature that pueblo lands were held communally; no individual allotments were ever made. (2) The Indian educational program, inaugurated in the latter part of the nineteenth century, was extended to San Juan in 1874. (3) The Pueblo Lands Board and later court rulings determined the validity of private claims to property located within the pueblo grant; provision was made to compensate Indians for titles to land within the grant where the decision was made in favor of private claimants. (4) With the passage of the Reorganization Act of 1934, which was accepted by San Juan, a new policy in the administration of Indian Affairs was brought into existence. Its most significant features are its recognition of the Indian tribal councils as governing bodies of the pueblos, promotion of an enlightened educational policy, an extension of improved medical services, and most important, a concerted effort to better the Indians' economic condition.

Agriculture was the chief means of subsistence of the pueblo peoples long before the appearance of the first Europeans. Recently, however, they have been able to increase their yield by means of new techniques and modern equipment. With the improvement of marketing facilities, the income derived from arts and crafts work has increased greatly. More recently, income from government employment, including work relief, has constituted another source of income. These economic factors, in addition to the improvement in medical care, have caused an increase in the standard of living. While this standard is by no means

high now, we can expect this change to be reflected in the data derived from our study of the population.

Following is a statistical summary of the population, land, and income of the San Juan Indians in 1938:[3]

Population	589
Irrigable farm land	2,000 acres
Forest and open grazing land	10,175 acres

Statement of income

Farm crops	$5,709
Livestock and prod.	1,495
Outside labor	26,808
Arts and crafts	1,801
Other native industries	412
Direct relief	385
Total	$36,610
Average income per capita	$62.16
Average income per family[4]	$279.47

2. POPULATION

A. Trends of total population

The general curve of population change for the San Juan Pueblo (Fig. 1) was plotted from the data found in the four supplementary sources discussed in the preface. The various figures from Table 1 are shown as points, and a smooth curve has been drawn through them to give a general picture of the population trends.

The inconsistencies to be found in the table and chart show that our information possesses varying degrees of validity. Of the two earliest population figures, the first listed in the table, 300 in 1680, is probably nearer the truth than the 400 given for 1707. The latter appears to include the Spanish population, and is less authentic than Bonilla's[5] figures for 1749, in which he differentiates between the Indians and the Spanish. Bonilla's total population is also more compatible with other independent estimates made at about the same time. Bancroft quotes without pertinent comment the figure 316 from Tamaron's report of his *visita* in 1760.

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[3] Annual Statistical Report, United Pueblos Agency, December 31, 1938.

[4] Calculated on the basis of 131 resident families.

[5] The sources referred to in this section are listed in column 4 of Table 1.

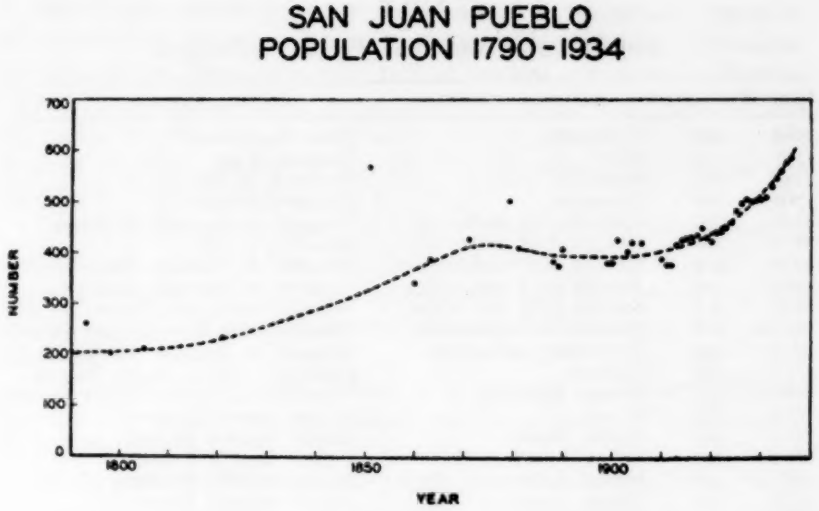

FIGURE 1

The earliest population figure for the pueblo in which any real reliance can be placed is that for 1790. The census for that year was thoroughly and carefully done, as was shown by an inspection of the original in the Santa Fe Archives. Each family was listed by the name and race of the man and wife, or other family head, together with the relationship of the other members to the head, as well as the age of each. The total amounted to 203 residents for the pueblo. The figure given by Bancroft for 1793 was higher, but for 1799, 202, is more in line with the 1790 figure. Considering that the epidemic of 1781 took a toll of over 100 lives, it would seem that Tamaron's figure of 316 for the year 1760 was substantially correct.

The report of 1805 and that of 1821 were cited as being the only exact sources for this period. The data for 1808 and 1809 were taken from a report made by John Ward, Indian Agent in 1867, and compare closely with the total for 1805.

In 1851, James S. Calhoun sent a census report to Washington in which he gave the figure 568 for San Juan. This seems high, and Calhoun himself throws doubt on the validity of the census. The Pojoaque, Tesuque, and Nambe Pueblos were demonstrated to have been underenumerated by approximately the same amount as that which seems to be in excess at San Juan.

TABLE 1

Population of San Juan Pueblo, 1680-1936

YEAR	POPULATION	ORIGINAL SOURCE	QUOTED SOURCE
1680	300	Ventacurt	Bancroft, p. 172
1707	400	Morfi	Thomas, p. 95
1749	404	Bonilla	Bancroft, p. 252
1760	316	Tamaron	Bancroft, p. 279
1790	203	Spanish civil authorities	Original in Spanish Archives
1793	260	Spanish civil authorities	Bancroft, p. 279
1799	202	Spanish civil authorities	Original in Spanish Archives
1805	210	Spanish civil authorities	Original in Spanish Archives
1808	201	Spanish civil authorities	Ward's Indian Agent Report for 1867
1809	208	Spanish civil authorities	Ward's Indian Agent Report for 1867
1821	232	Franciscan authorities	Original in Spanish Archives
1851	568	Calhoun	Calhoun's Indian Agent Report
1860	341	Deputy Marshall	Ward's Indian Agent Report for 1867
1863	385	Ward	Indian Agent's Report
1871	426	Indian Agent	Indian Agent's Report
1879	500	Indian Agent	Indian Agent's Report
1881	408	Indian Agent	Indian Agent's Report
1888	381	Indian Agent	Indian Agent's Report
1889	373	Indian Agent	Indian Agent's Report
1890	406	Special Report, U.S. Census	Special Report, U. S. Census
1899	378	Commissioner's Report	Indian Agent's Report
1900	379	Commissioner's Report	Indian Agent's Report
1901	425	Commissioner's Report	Indian Agent's Report
1903	402	Commissioner's Report	Indian Agent's Report
1904	419	Commissioner's Report	Indian Agent's Report
1906	419	Commissioner's Report	Indian Agent's Report
1910	387	U. S. Census	U. S. Census Report
1911	377	U. S. Indian Service	Tabulation sheet
1912	376	U. S. Indian Service	Tabulation sheet
1913	416	U. S. Indian Service	Tabulation sheet
1914	425	U. S. Indian Service	Tabulation sheet
1915	428	U. S. Indian Service	Tabulation sheet
1916	431	U. S. Indian Service	Tabulation sheet
1917	435	U. S. Indian Service	Tabulation sheet
1918	449	U. S. Indian Service	Tabulation sheet
1919	430	U. S. Indian Service	Tabulation sheet
1920	422	U. S. Indian Service	Tabulation sheet
1921	439	U. S. Indian Service	Tabulation sheet
1922	441	U. S. Indian Service	Tabulation sheet
1923	450	U. S. Indian Service	Tabulation sheet
1924	458	U. S. Indian Service	Tabulation sheet
1925	483	U. S. Indian Service	Original Census
1926	497	U. S. Indian Service	Original Census
1927	505	U. S. Indian Service	Original Census
1928	500	U. S. Indian Service	Original Census
1929	503	U. S. Indian Service	Original Census
1930	505	U. S. Indian Service	Original Census
1931	510	U. S. Indian Service	Original Census
1932	530	U. S. Indian Service	Original Census
1933	546	U. S. Indian Service	Original Census
1934	561	U. S. Indian Service	Original Census
1935	578	U. S. Indian Service	Original Census
1936	586	U. S. Indian Service	Original Census

Subsequent census reports are to be found in the annual reports of the various Indian Service Superintendents. Although an Indian census was required of them each year, lack of interest, personnel, and funds caused guesses to be made more often than a thorough count. The population counts between 1863 and 1910 that are cited in Table 1 are those in which clear evidence was given in the report that a census was made; after 1911, annual figures are given.

The statistics gathered for the federal census of 1890 were carefully checked with those persons who had knowledge gained through residence in the area. As this was supplemented with conferences with the leaders of the Indians, the report represents the consensus of many opinions.

Following the thorough census of 1936, the results were checked in every way possible and were finally certified as correct by the Council of the Pueblo.

A test was applied to the most recent census of the San Juan Pueblo to determine its accuracy. The population change from census to census was taken over the period 1926-36, the increase amounting to 95 persons. The excess of births over deaths computed for the same time span was 92. The difference of three is annually less than a thousandth of the mean population for the period.

It can be seen that the population curve has been constructed from a variety of sources. Undoubtedly errors exist in individual censuses, even in those culled for use here. However, the general trends in the change of population have been made evident. There was apparently a decrease of about 100 in the latter half of the 18th century, so that around 1800 the population was approximately 200 persons. By 1860, it had risen to twice this number, and after levelling off, it has risen consistently since 1910 to the value of 586 in 1936. The present population is thus almost a 200 percent increase over the population in 1800, and a 46 percent increase over that of twenty-five years ago. Since 1910 the population increment, computed by the method of least squares, has been at the rate of 1.53 percent per year.

It has been impossible to determine accurately the trend of the Spanish population within the study area with the information available because the bounds of this area are not contiguous with those of the parish to which the records were often confined. Futhermore, the parish boundaries have undergone occasional change. The totals that follow are presented only as approximations of the number of Spanish persons within the study area. The figures listed for the first four dates were

probably ultimately derived from the same records of births and deaths that have been employed in this study. The 1910 population was taken by the parish priest; that for 1930 was estimated from the 1930 census on the basis of the ratio of the 1910 federal census to the church enumeration.

YEAR	SOURCE	SPANISH POPULATION
1749	Bonilla	346
1760	Tamaron	575
1790	Spanish Civil Authorities	1,330
1793	Spanish Civil Authorities	2,173
1798	Spanish Civil Authorities	1,971
1910	Church Parish Census	2,019
1930	Estimate from U. S. Census	2,500

It would appear that there was but a small increase in the Spanish total in the area during the period 1800-1910, with a later increase of approximately twenty-five percent by 1930. Undoubtedly large fluctuations in numbers did take place between 1800 and 1910, but the figures indicate that by the earlier of these dates the principal migration of the Spanish to the area was over.

B. Population characteristics—Sex

Table 2 shows the relationship between numbers of males and females for the pueblo and non-pueblo populations. The data for the earlier years of the table were taken from the sources listed in Table 1; those for 1910 and 1920 were taken from the census reports of those years. The ratios indicate almost an equality of sexes at the beginning of the 19th century. However, in recent years we find an increased predominance of males, which may be due to the elimination of the necessity of fighting with the nomadic Indians in the region.[6] These later figures are more comparable with the sex ratios for the United States as a whole, which have varied between 102.2 and 106.0 in the period 1820-1930.

The sex ratios of age groups for the 1936 San Juan population are compared in Table 3 with the Indian language stock to which the pueblo belongs as well as with populations of New Mexico and the United States. The number of males under fifteen years of age is consider-

[6] See Introduction:—campaigns by the U. S. Army.

TABLE 2

Relationship between number of males and females for the pueblo and non-pueblo populations

YEAR	MALES PER 100 FEMALES	
	Pueblo	*Spanish Area*
1790	99	102
1798	80	...
1805	100	...
1821	102	95
1863	97	...
1890	126	...
1910	113	104*
1930	109	103**
1936	104	...

* White population, Rio Arriba County, U. S. Census, 1910.
** Native white population, Rio Arriba County, U. S. Census, 1930.

ably less than for the whites and Negroes, but is greater at the older ages. This observation also holds true for the Tanoan stock. The high pueblo ratio at 65 years and over, 238, is unimportant due to the small number of persons in that age group.

TABLE 3

Comparison of sex ratios (males per 100 females) by age groups

	SAN JUAN PUEBLO 1936	TANOAN STOCK 1930	NEW MEXICO 1930	UNITED STATES, 1930			
			White*	TOTAL	White*	Negro	TOTAL
Under 5	92	97	101	101	104	99	103
5-14	79	98	102	101	103	99	102
15-24	107	103	101	101	99	88	98
25-44	108	125	105	106	101	92	102
45-64	135	129	126	129	107	117	109
65 and over	238	160	143	144	100	103	101
Total	104	112	107	107	102	97	102

* Native white of native parentage.

C. Population characteristics—Age

Only a few of the many tabulations listed in Table 1 show a classification of the population by age. Since the individual ages were given in the census of 1790, a comparison of sex and age distribution for this year with the years 1930 and 1936 has been made in Table 4. The table shows, in addition to the pueblo distribution, figures for the surrounding area compared with the white population of the county in 1930.

The data for 1790 does not show a normal distribution because of the effect of the smallpox epidemic of 1781; this resulted in a small proportion of persons of 10-24 years of age. The figures are interesting, however, as they suggest the economic difficulties which must have arisen in a group in which over one-fourth were less than five years of age, as compared to eleven percent in 1930. In 1790, half of the pueblo Indians were between the ages of 15 and 64 years, as compared with sixty-one percent in 1930. Of the population over 65 years of age little can be said, since the number of persons of such age was small.

In the Spanish population, the age distribution differs somewhat from the pueblo, and is more comparable to that of the later date. The proportion of persons under five years was 21 percent, as compared with 14 percent in 1930; between the ages 5-14, the proportions were equal, with 26 percent for both dates; at ages 15-64, we find 51 percent in 1790, as compared to 56 percent in 1930.

Age distributions were also found for three other periods of time, but the groupings were such that comparison with the data presented above is difficult. In 1805, thirty-seven percent of the pueblo population is listed as being under 12 years of age, while 42 percent were between 12 and 45 years of age. In 1863, the proportion of adults (females between 16 and 70, and males between 18 and 70) is given as 65 percent. The census distribution of San Juan Pueblo in 1890 is as follows:

Age	*Number*	*Percent*
Under 6 years	60	14.8
6-18 years	96	23.6
19-70 years	242	59.6
over 70 years	8	2.0
	406	100.0

TABLE 4

Age and sex distribution of San Juan, 1790, 1930, and 1936

PUEBLO

AGE	Numbers									Percentages								
	1790			1930			1936			1790			1930			1936		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0- 4	28	25	54*	24	33	57	33	36	69	28	25	27	9	14	11	12	13	13
5-14	19	21	40	57	65	122	64	81	145	19	21	20	22	27	24	23	30	26
15-24	16	12	28	47	52	99	49	46	95	16	12	14	18	22	20	17	17	17
25-44	23	31	54	74	51	125	70	65	135	23	30	27	28	21	25	25	24	25
45-64	10	8	18	46	36	82	46	34	80	10	8	9	18	15	16	16	13	15
65 & over	5	5	10	14	4	18	19	8	27	5	5	5	5	2	4	7	3	5
Total	101	102	204	262	241	503	281	270	551	101	101	102	100	101	100	100	100	101

WHITE POPULATION

AGE	Numbers						Percentages					
	1790			1930			1790			1930		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
	Spanish Area			Rio Arriba County			Spanish Area			Rio Arriba County		
0- 4	139	137	279**	1358	1478	2836	21	21	21	14	15	14
5-14	188	157	345	2594	2549	5143	28	24	26	26	26	26
15-24	122	125	247	1863	1845	3708	18	19	19	19	19	19
25-44	147	152	299	2274	2388	4662	22	23	23	23	25	24
45-64	57	65	122	1384	1100	2484	9	10	9	14	11	13
65 & over	5	14	19	498	322	820	1	2	1	5	3	4
Unknown	8	6	14	3	14	17	1	1	1	..	..	..
Total	666	656	1325	9974	9696	19670	100	100	100	101	99	100

* Total contains 1 of unknown sex.
** Total contains 3 of unknown sex.

D. Population characteristics—Family size

Sufficient information is available to make possible an analysis of family size for the study area in 1790. The number of families and their mean and median sizes are shown in Table 5. The mean size of the pueblo family was smaller (4.2) than the Spanish (4.7), even when those designated as *sirviente* in the latter group were eliminated (leaving 4.5); the differences, however, are not statistically significant.

TABLE 5

Mean, median, standard deviation and coefficient of variation of family size

	NUMBER	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
Pueblo, 1790	49	4.2	4.4	1.7	42
Spanish area, 1790	286	4.7	4.7	2.3	50
Spanish area, excluding servant, 1790	286	4.5	4.6	2.1	48
Pueblo, 1931	124	4.3	3.8	2.6	60

The leading unit in the household in both groups was the man and wife; 75.5 percent of the pueblo families and 76.3 percent of the Spanish families were thus headed. Those having a man only as head amounted to 12.2 percent in the pueblo and only 4.9 percent among the Spanish; those having a woman only as a head comprised 12.2 percent of the total in the pueblo, and 17.8 percent among the Spanish. 44 of the 51 Spanish families with a woman alone as head had children or relatives in the family group. It is evident that the widowed Spanish male had greater success at remarriage than the Spanish female.

The pueblo families included children in a greater percentage of cases than did the Spanish (85.7 percent as against 80.1 percent); relatives were also included to a greater degree (18.4 percent compared with 10.8 percent). Eleven percent of the Spanish families possessed servants, usually of Indian or mixed-Indian origin.

As an additional comparison, the last row of Table 5 shows similar data for the 1931 pueblo population. In that year the mean family size

was larger, but this is due to the presence in greater proportion of large-sized families, as the median family size is smaller than in 1790.

In 1931, 61 percent of the pueblo families were headed by a man and wife, 27 percent by a man only, and 12 percent by a woman only. Three-fourths of the families in 1931 contained children as compared with 85.7 percent in 1790; 22.0 percent included relatives as compared with 18.4 percent in 1790.

It would appear from these figures that the pueblo family now possesses many more of the characteristics of an aging stock than in 1790; there are proportionately fewer children, more families with only a man or woman as head, and a smaller median family size. It should be remembered that the 1790 population is that of a group nine years after a disastrous epidemic and in the full course of recovery. Thus, the comparisons made above are only valid to the extent to which one accepts the 1790 description, with its relation to the epidemic, as typical for that period.

3. NATALITY

A. Methods of analysis

After translation and transcription of the church records, the births for each year were tabulated by sex,[7] as well as by place of residence of the family. The locality was classified according to pueblo, Spanish area, outside the study area, or outside the parish (of which there were scattered entries). In the earlier years, occasional births to Indians not native to San Juan were entered. These were presumably the natality records of slaves captured in warfare and kept in captivity; they were listed separately.

Annual tabulations of the date of birth were made wherever included in the records. In the two periods of years, 1726-1766 and 1772-1775 inclusive, the entries recorded the date of baptism only, and these designations had to be used for tabulation instead of the date of birth. The error involved by this procedure was small and amounted to only one or two births a year.[8]

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[7] The sex ratios (males per 100 females) were as follows: Total, 102.5; Pueblo, 97.1; Spanish area, 104.3.

[8] Sample tabulations of intervals between birth and baptism for those years in which both dates were given showed a mean of 7.4 days and a median of 5.6 days' interval between them, the standard deviation being 15.1 days.

Following this primary tabulation of the births, certain corrections were applied to those years or groups of years in which discrepancies were noted. These were as follows:

Place of birth not entered. This occurred for a total of twenty years at various intervals throughout the period studied, the largest span being seven years. However, it is possible to distinguish the Spanish names used by the San Juan Indians from those used by the Spanish population, and from this the relative place of habitation can be derived. One of us (E. H. P.) who had been a resident in the pueblo for several years in close contact with the parish families, acquired the ability of recognizing this distinction.[9] The names entered during these years in which the race was not designated were divided into Spanish and Indian according to her decision.

The tabulated totals of Spanish births, as indicated by the name, were then subdivided into a total for the Spanish area and the rest of the parish outside the study area. This was done by employing the mean ratio (Spanish area to the parish as a whole) of the totals for the four years preceding and following the period of name-codification.

Assignment of births when place was omitted. These differ from the first corrections by being omissions of locality during the years in which this entry had regularly been made. Where these were encountered, the births of adjacent years were examined to see if the family residence was given in the record of other children of the family. In a substantial majority of the cases this search was successful. The remainder were allocated to pueblo or Spanish area by name, as described above. The number of such births was too small, as a rule, to be further refined by partial allocation to the Spanish group outside the study area.

Missing pages. It was apparent that certain pages had been removed from each of the records for three individual years. These omissions were corrected by dividing the number of births recorded for the year by the number of months to which they apply; the average number of births per month having been obtained, this figure was then multiplied by the number of months for which there had been records on the missing pages.

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[9] A test sample of 154 names was taken from years that were adjacent to those in which the race and locality were unknown. The result showed that she was successful in designating correctly 88.3 percent of them as to race through the use of the given and family names of the child and the father, and the maiden name of the mother.

Intervals between the tenures of priests. In the earlier years especially, a period of time varying from several days to a few months occurred between the tenures of the various priests. The number of births which were not recorded during these intervals was estimated by calculating the average number for a week or a month during the portion of the year where entries were made and applying it to the length of time where no records were kept.

Omitted years. The general summation of the birth time-series was performed by means of five-year totals. In certain years, 1741-43, 1745, and 1853-54, defects in records were evident. These years were not included for the five-year intervals in which they occurred. The period 1820-24 was one of markedly defective records, which, in addition, contained no record of place of birth. The best policy appeared to be to omit this period from the study.

B. Trend of total births

Following the above adjustments, a total of 12,632 births was obtained for the 209-year period 1726-1934. Of these, 3,060 or 24.2 percent occurred in the pueblo and 9,572 or 75.8 percent in the study area outside the pueblo. The adjusted totals for births during the five-year intervals are given in Table 6.

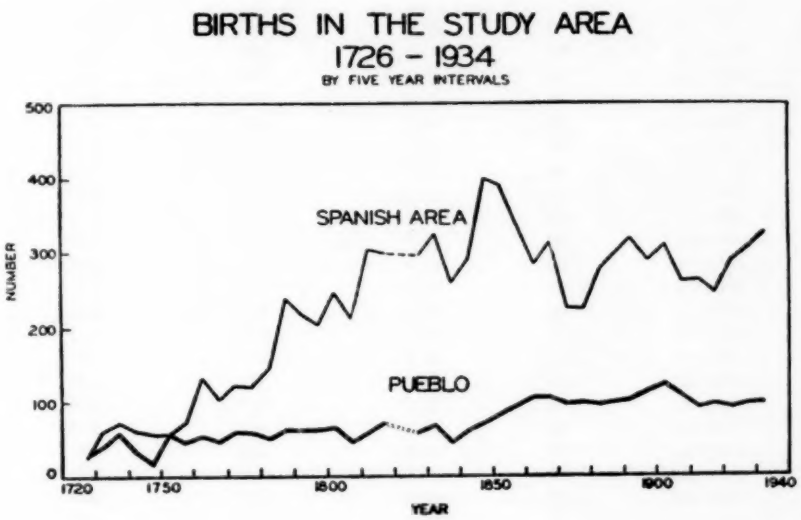

FIGURE 2

TABLE 6

Natality in the study area, 1726-1934 and annual birth rates (per 1,000 population) for the pueblo, 1790-1934

YEARS	PUEBLO		SPANISH AREA	TOTAL
	Number	Birth Rate	Number	Number
1726-29	26	.....	25	51
1730-34	41	.....	61	102
1735-39	58	.....	72	130
1740-44	33	.....	62	95
1745-49	19	.....	57	76
1750-54	56	.....	57	113
1755-59	46	.....	83	129
1760-64	54	.....	134	188
1765-69	47	.....	104	151
1770-74	60	.....	123	183
1775-79	59	.....	121	180
1780-84	51	.....	147	198
1785-89	72	.....	239	311
1790-94	63	62.4	216	279
1795-99	62	61.1	202	264
1800-04	65	63.4	246	311
1805-09	47	44.8	212	259
1810-14	57	53.3	304	361
1815-19	70	62.8	299	369
1820-24	....	.....	.....	.....
1825-29	60	48.6	296	356
1830-34	69	52.3	325	394
1835-39	45	32.3	258	303
1840-44	60	40.5	291	351
1845-49	70	44.7	400	470
1850-54	82	49.2	390	472
1855-59	94	52.8	335	429
1860-64	104	55.3	283	387
1865-69	105	52.5	314	419
1870-74	97	47.0	225	322
1875-79	99	47.9	224	323
1880-84	97	47.8	278	375
1885-89	99	49.9	299	398
1890-94	103	52.3	320	423
1895-99	113	57.5	289	402
1900-04	122	61.9	310	432
1905-09	108	54.0	261	369
1910-14	92	45.2	263	355
1915-19	96	45.5	245	341
1920-24	92	41.3	290	382
1925-29	96	39.0	306	402
1930-34	98	36.4	327	425

The curves for the pueblo and the Spanish area, shown in Fig. 2, differ markedly. The former shows a rather consistent value during the years from 1750 to 1835, with only a slight upward trend. After 1835-39, the curve rises steadily during the next thirty-five years to 104 in 1860-64. It fluctuates very little thereafter, with the excepton of a minor rise in 1895-1909. In the case of the Spanish curve, however, a rapid rise takes place during the period 1726 to 1814. Following 1815, it no longer shows a consistent rise, but fluctuates widely around approximately 300 births. The peak of the entire curve is reached in 1845-59, with 400 births, which subsequently is reduced to 224 in 1875-79. The curve then rises steadily until 1890-94, when it again recedes. Since 1915-19, a sharp rise has again occurred.

One is at a loss to explain the behavior of the Spanish area curve of births. The curve seems not to be a reflection of the incomplete phases of recording or of the influence of epidemics, since such would also be in evidence in the pueblo curve. The fluctuations do not conform in any way to the tenures of the various priests.

The pueblo curve is remarkably uniform, considering the small population involved, and can be regarded as evidence of the essential accuracy of the pueblo birth statistics.

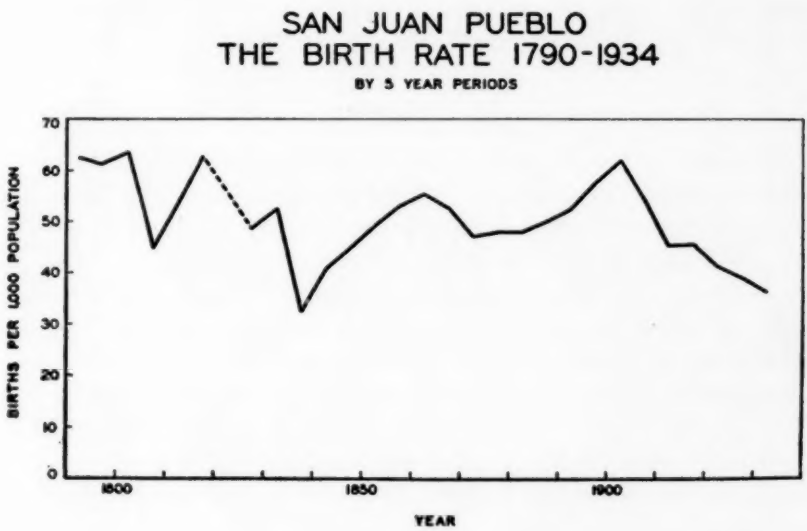

FIGURE 3

The birth rate curve in Fig. 3 is the result of applying the smoothed population curve of San Juan Pueblo [10] to that of the births in Fig. 2 for the years since 1790. The result, therefore, contains the errors inherent in the two, and must be interpreted with considerable caution. The low point on the curve at 1835-39 may have been due to the combined typhoid and smallpox epidemic of the period 1835-44. We can doubtfully speak of three peaks in the curve, the first, 1815-19, the second, 1860-64, and the third 1900-04; the intervals between them are 45 and 40 years respectively. The ascent to the last peak of 62 per 1000 population was begun in 1870-74; the decline from it has been sharp and consistent to the rate in 1930-34 of 36.4 per 1000 population. The trend has been observed in the population changes of many other groups; as the environmental and economic conditions improve, the birth rate falls.

The lack of a population curve prevents the computation of birth rates for the Spanish area. If the population data given above (see Section 2.—Population: the latter part of "Trends of Total Population") are applied, however, to the five-year totals of births, centering in the year in which the census was taken, one obtains rates of 33 and 18 per 1000 for 1790 and 1793 respectively, and of 25 and 26 for the periods centering on 1910 and 1930. All of these rates are well below those of the pueblo and tend to indicate a deficiency in the births recorded, especially for the earlier period.

C. Plurality

It was possible to examine the birth lists from 1800 onwards for multiple births. The majority of these were designated as such, and the remainder were obtained in the baptismal records by checking the lists by dates, place of birth, and names of parents.

Records of 68 cases of multiple births were found, of which eleven were in the pueblo, and the remaining 57 in the Spanish area. On the basis of the total recorded births during the 135-year period, the ratio of plural births per 1000 baptisms in the pueblo was 4.8, and in the Spanish, 7.2. An application of the Chi-square test shows the difference to be statistically insignificant. Both ratios are relatively low, however; the figure in 1930 for the U. S. Birth Registration Area was 11.6, and for

[10] See Fig. 1.

New Mexico, 12.6. The low figures for the study area suggest a possible racial difference in the incidence of twinning.[11]

One case of triplets was recorded, occurring in the Spanish area in 1930; the infants were all males. Of the 67 twin births (the numbers are too small to break down by area), 17 were both males, 22 both females, and 28 a male and a female. Expectancy on the basis of the binomial distribution was respectively 17, 17, and 33. The difference between the observed and expected data are statistically insignificant.

The above findings, of course, exclude stillbirths and also livebirths where the infants died before baptism. The loss due to the latter is not apt to be large because of the practice of early baptism; the defect in the statistics due to unrecorded stillbirths can only be conjectured.

D. Fertility

In 1931, Aberle [12] conducted a study of the pregnancies and birth intervals among the San Juan pueblo women. She reported between nine and fourteen pregnancies in a reproductive span. The modal birth interval calculated for women with two or more children was shown to be approximately twenty-four months for the San Juan and Santa Clara pueblo women, both today and a century ago, which is the same as the figure obtained for white women in the United States for similar periods.

The fertility ratio which, in addition to the reproduction span, takes into consideration the number of women of child-bearing age, shows a decrease in fertility in comparison with modern fertility ratios (see Table 7). (Pueblo 1256 in 1790, Spanish Area 1007 in 1790). The pueblo ratio (553 in 1930, 621 in 1936) ranks in value with that of the State of New Mexico (570 in 1930) and for the Indian population of the United States (680 in 1930).

4. MORTALITY

A. Trend of total deaths

The annual death totals were adjusted in a manner similar to that described above for births.[13] This was necessary for non-entries of

[11] G. W. D. Hamlett: Human twinning in the United States: Racial frequencies, sex ratios and geographical variations. *Genetics*, 20:1935, pp. 250-258.

[12] S. B. D. Aberle: Frequency of pregnancies and birth interval among pueblo Indians. *Amer. Jr. Phys. Anthropol.*, Vol. 16:1, 1931, pp. 63-80.

[13] See Section 3.—Natality: under "Methods of analysis".

TABLE 7

Comparison of fertility ratios of different periods

YEAR	WOMEN 15-44 YEARS	CHILDREN UNDER 5 YEARS	RATIO OF CHILDREN TO WOMEN
	Pueblo		
1790	43	54	1256
1930	103	57	553
1936	111	69	621
	Spanish Area		
1790	277	279	1007
	New Mexico		
1930	94,486	53,853	570
	United States		
1930 Native white	22,618,172	9,899,608	438
1930 Negro	3,131,885	1,230,206	393
1930 Indian	68,598	46,680	680

place of death, intervals between tenures of priests, and omitted years. Birth records were examined to determine which years were actually missing, since the totals of annual deaths were so small that chance distributions could well have accounted for years in which no deaths were recorded, especially in the pueblo. It was also impossible, for the same reason, to discern from dates of deaths whether missing pages meant that death records had been removed from the volumes, or whether pages had been torn out because they had been spoiled and the material recopied on the next page.

The adjusted deaths over the 209-year period 1726-1934 total 5,485. Of these, 1,846, or 33.7 percent, were in the pueblo and the remaining 3,639 (66.3 percent) in the Spanish area.

A comparison of death totals with those of births shows a marked discrepancy in the former. Even if the birth records were complete, which they are not, the total deaths over such a period of time as 209 years should approximate the number of births. For the pueblo the death total is 61.2 percent of that for births; for the Spanish area it is only 38.0 percent. The discrepancy is serious, particularly in the case

TABLE 8

Mortality in the study area, 1726-1934, and annual death rates (per 1,000 population) for the pueblo, 1790-1934

YEARS	PUEBLO		SPANISH AREA	TOTAL
	Number	Death Rate	Number	Number
1726-29	46	.....	7	53
1730-34	11	.....	4	15
1735-39	3	.....	4	7
1740-44	1	.....	2	3
1745-49	38	.....	16	54
1750-54	48	.....	17	65
1755-59	38	.....	9	47
1760-64	60	.....	20	80
1765-69	41	.....	22	63
1770-74	41	.....	16	57
1775-79	24	.....	23	47
1780-84	122	.....	304	426
1785-89	58	.....	160	218
1790-94	57	56.4	114	171
1795-99	39	38.4	60	99
1800-04	43	42.0	152	195
1805-09	28	26.7	58	86
1810-14	60	56.1	134	194
1815-19	83	74.4	199	282
1820-24	....	.....	.....	.....
1825-29	36	29.1	126	162
1830-34	21	15.9	46	67
1835-39	7	5.0	37	44
1840-44	43	29.1	168	211
1845-49	23	14.7	132	155
1850-54	26	15.6	78	104
1855-59	42	23.6	119	161
1860-64	41	21.8	79	120
1865-69	41	20.5	85	126
1870-74	46	22.3	70	116
1875-79	30	14.5	46	76
1880-84	43	21.2	50	93
1885-89	35	17.6	61	96
1890-94	71	36.0	158	229
1895-99	69	35.1	194	263
1900-04	46	23.4	148	194
1905-09	92	46.2	102	194
1910-14	64	31.4	110	174
1915-19	78	37.0	133	211
1920-24	49	22.0	127	176
1925-29	58	24.0	114	172
1930-34	44	16.4	135	179

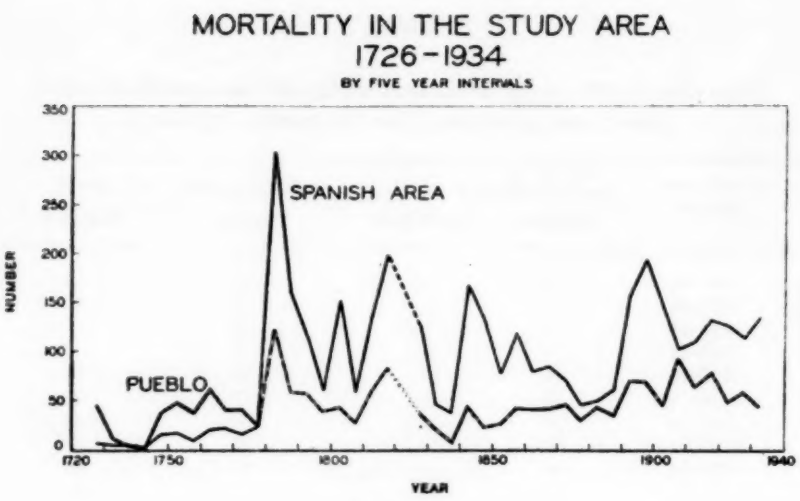

FIGURE 4

of the Spanish. The curves of mortality, even more than the natality curves, should accordingly be regarded as approximations to the true situation within the area studied. They are presented here only to indicate the general trend of mortality and its evidenced relation to the

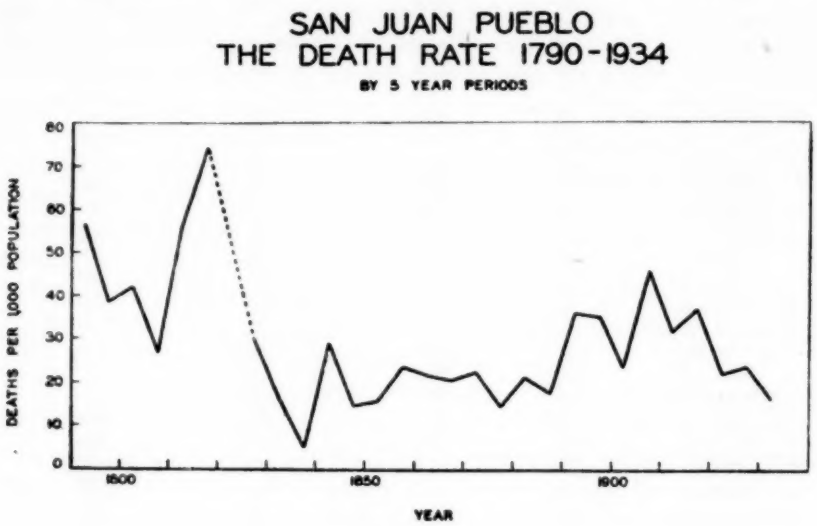

FIGURE 5

population curve. The five-year totals of deaths are given in Table 8 and Fig. 4; the corresponding death rates are in Fig. 5.

Mortality in the pueblo fluctuated markedly during the period 1726-1849. Severe epidemics occurred from time to time to double and even treble the previous number of deaths. From 1850-54 to the turn of the century the deaths slowly increased; subsequent to 1905-1909 the number has been decreasing. The corresponding curve for the Spanish area shows an even more marked variation. After the low recorded mortality previous to 1780-84, sharp and irregular fluctuations ensue throughout the entire nineteenth century, the last high peak occurring in 1895-99.

The curve of the pueblo death rate [14] reflects the highest rate (74 per 1000 population) in the period 1815-19. Following an epidemic period in 1849-54, the curve irregularly rises to a rate of 46 per 1000 in 1905-09. From this point it has since receded to 16 per 1000 in 1930-34.

B. Epidemics

Lack of completeness necessarily limits description of the total span of mortality rates, but when daily records are available, the time, and to some extent, the magnitude of sharp and abrupt fluctuations may be determined with some accuracy. It is obvious that the sudden changes in mortality which have occurred from time to time can largely be attributed to epidemics. The more prominent of the nine which are recorded are worthy of mention; that of 1855-59 was apparently not sharply epidemic in nature, the deaths being somewhat evenly distributed over the entire five-year period. The remaining eight are shown in Figs. 6 and 7.

The epidemic of 1781 was the greatest in the modern history of the Southwest. Of the 9,104 inhabitants of the mission pueblos enumerated in 1760, Bancroft states that 5,025 died during this epidemic. In San Juan, the annual recorded burials for seven years were:

Year	*Pueblo*	*Spanish area*
1777	3	2
1778	2	5
1779	8	12
1780	15	58
1781	95	216
1782	1	5
1783	2	6

[14] Shown in Fig. 5. No curve has been drawn for the Spanish area because of the lack of a population curve.

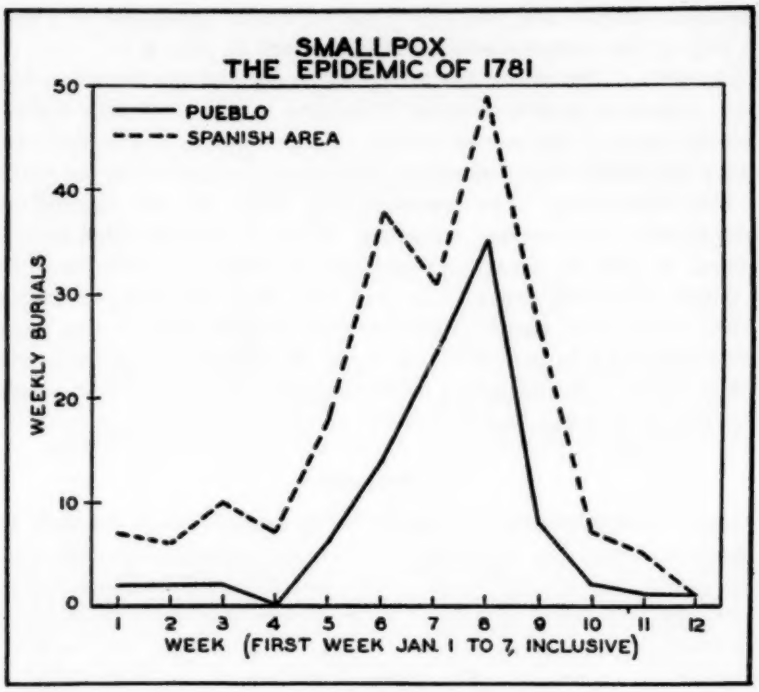

FIGURE 6

The relative magnitude of the attack is revealed when one recalls that in 1790 the pueblo population was 203, while that of the Spanish area was 1330.

This epidemic began in San Juan in the latter part of January, reached its peak in the week of February 15-19, and rapidly receded to normal by the middle of March. The curves, especially that for the pueblo, are of the type described by Brownlee[15] as occuring only when the exhaustion of susceptibles limits the rise in numbers of deaths. He ascribes this situation as existing in those instances of rapid and severe mortality from smallpox which were frequent throughout the world before the nineteenth century.[16] The curves are Type IV of Pearson's frequency curves and have almost identical mathematical constants.

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[15] John Brownlee. Statistical studies in immunity; the theory of an epidemic. *Proc. Roy. Soc. of Edinburgh.*, Vol. 26, 1905-1906, p. 484.

[16] It is interesting to note that the pueblo curve is quite similar to that of the calamitous Boston smallpox epidemic of 1721 when out of a population of 5,000 inhabitants not protected by a previous case of the disease, 4,500 were attacked.

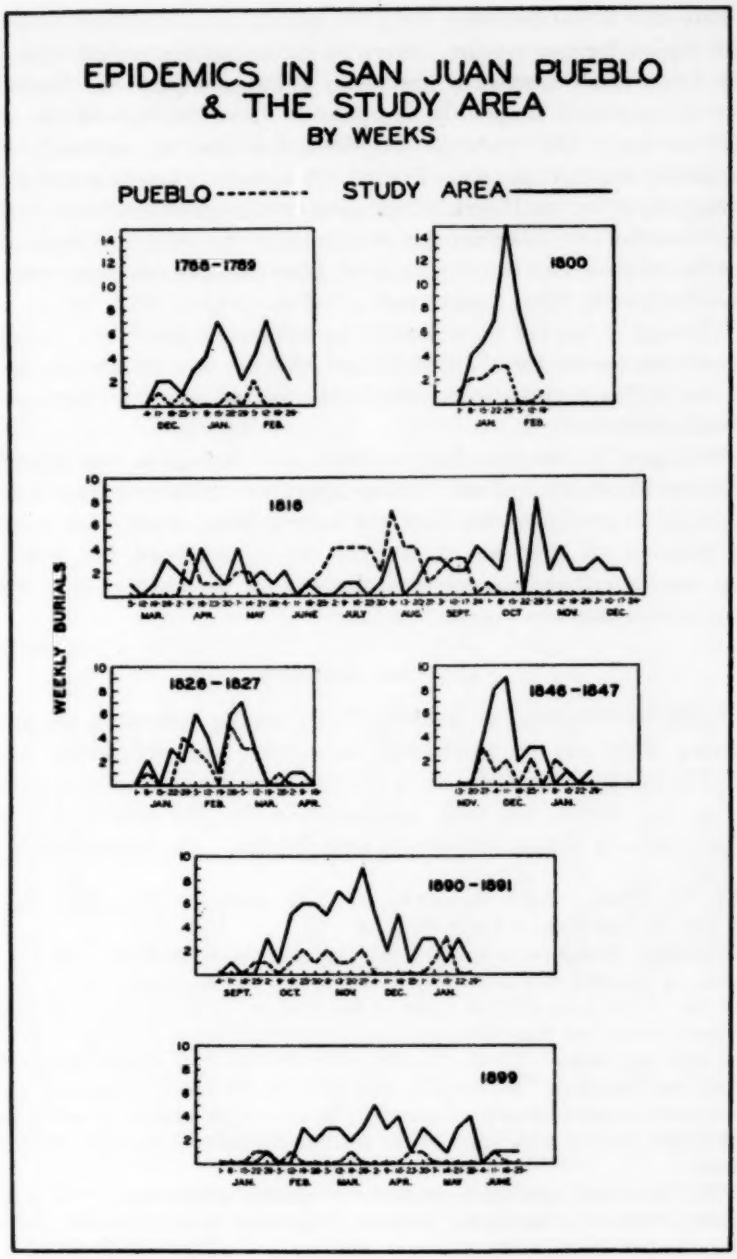
EPIDEMICS IN SAN JUAN PUEBLO
& THE STUDY AREA
BY WEEKS
PUEBLO ---------
STUDY AREA ———
WEEKLY BURIALS
1788-1789
1800
1816
1828-1827
1846-1847
1890-1891
1899

FIGURE 7

It is safe to surmise that the 1781 epidemic was the first to appear in the region for many years, otherwise its devastation would have been limited to a small number of previously uninfected persons. Smallpox, however, appeared frequently in epidemic form throughout the nineteenth century. The epidemic of 1788-89 was also one of smallpox, as presumably was that of 1800 (Fig. 7). Vaccination was first introduced in 1804 according to Bloom[17] and earnest attempts were made by the Spanish authorities to reduce the prevalence of the disease;[18] reports are available to show that in 1805, at least 3,610 persons were vaccinated in New Mexico; in 1809, 1,097, and in 1810, 1,157.

Although it has not been possible to definitely identify the causes of the epidemic curves for 1816, 1826, and 1846-47, it is certain that smallpox was still a major disease and broke out in epidemic form at occasional intervals.

The cause of the San Juan epidemic of 1890-91 is also not clear. However, the reports of the Indian agent for 1889 and 1891 contain references to smallpox and diptheria among children of other pueblos. The epidemic of 1899 was apparently due to smallpox, but when the agent was describing the epidemic throughout the pueblos as a whole, he mentioned only one case at San Juan.[19]

C. Infant mortality

As the record of age at death was not routinely entered in the church registers, little can be ascertained concerning the differences in the mortality rate over the life span in the San Juan area. In certain periods the age was noted, but only spasmodically for the adults, and with rather indefinite figures for infants and children. Our summary of the

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[17] L. B. Bloom. Early vaccination in New Mexico. Publication No. 27. *Hist. Soc. of New Mexico, Santa Fe,* 1924.

[18] Governor Alencaster ordered in 1805 that a count of those who had not had smallpox be included as a part of the census which was soon to be taken. It was found that of the 3,463 children under 12 years of age in the pueblos and Spanish settlements of central New Mexico, 1,105, or less than one-third had not been infected with the disease. Of the 77 children in the San Juan Pueblo, 50 had been afflicted with smallpox. No analysis was given in the case of men and women because, as the alcalde states in a footnote: "in all this jurisdiction no one has been found who is more than six years of age who has not suffered from the sickness of smallpox".

[19] This report also mentions an incidence of malaria in almost all of the pueblos, especially in those of Sandia and Cochiti; in previous years, reference had been made to the prevalence of the disease at San Juan.

data of the last named group is only an inexact approximation of mortality at very young ages. In regard to the proportion of deaths under one month to the deaths under one year the figures seem to be fairly reliable.

Summarized in Table 9 are the findings regarding infant mortality during those periods in which attempts were made to indicate the age at death. Three designations were customarily used: (1) the age by days, weeks, or months was given, (2) age was listed as "one year", and (3) the death was merely characterized as that of a "child".[20] All rates in the table are based upon the number of births adjusted as described in the section on natality.

The results do not indicate any substantial reduction in infant and child mortality during the period studied for either the pueblo or the Spanish areas. The high rates for 1780-1819 are due to the smallpox epidemics of that period. The rate for the pueblo in 1925-34 of deaths entered as under one year and one year (B, Table 9, 222 per 1,000 births) appears to be a reasonably accurate measure of infant mortality, for it

TABLE 9

Infant and child mortality in the study area. Ratios per 1000 births

YEARS	PERIOD OF YEARS	PUEBLO			SPANISH AREA		
		A	B	C	A	B	C
1746-1764	19	240	316	327	19	31	35
1780-1819	40	115	123	442	48	60	321
1840-1849	10	24	89	202	35	60	184
1850-1874	25	33	47	162	20	31	124
1875-1899	25	14	25	143	10	14	135
1900-1924	25	26	45	234	22	34	104
1925-1934	10	160	222	222	115	134	134

A—Includes deaths entered as under one year only.
B—Includes deaths entered as under one year and one year.
C—Includes deaths entered as under one year, one year and 'child'.

[20] The first is a proper designation of death under one year of age, and the second also signified an infant death in the vast majority of cases. The third, however, seems to have been used in different ways: to indicate deaths of children under one year, of children of ages less than one year together with those over one year, or to denote the latter only.

TABLE 10

Proportion of deaths accurately determined as dying under one year of age which died under one month of age

YEARS	NUMBER OF INFANT DEATHS				DEATHS UNDER ONE MONTH AS PERCENTAGE OF DEATHS UNDER ONE YEAR	
	Pueblo		Spanish Area			
	Under one month	Under one year	Under one month	Under one year	Pueblo	Spanish Area
1775-99	28	50	21	123	56	17
1800-24	20	46	25	124	44	20
1825-49	1	15	18	56	7	32
1850-74	12	26	12	53	46	23
1875-99	4	37	11	67	11	16
1900-24	5	46	10	57	11	18
1925-34	8	31	13	66	26	20

agrees with that of 231 per 1,000 live births obtained by Aberle[21] in a careful study of infant mortality in the same pueblo for the years 1885-1930.

Table 10 shows the proportion of infants who died under one month of age, out of the total number whose date of death had been ascertained by matching birth and death records as having occurred in their first year of life. Modern experience demonstrates that those dying before reaching the age of one month are usually those injured or weakened by birth injuries or congenital abnormalities; those dying after reaching the age of one month succumb to disease or other environmental disarrangement. Ruling out the data for the uncertain period 1825-49, the table indicates that prior to 1875 an unduly large proportion of infant deaths in the pueblo were under one month, a condition which has since improved. Such a change is not observable for the Spanish area. If the modern interpretation of neonatal mortality (deaths under one month of age) holds for the entire period under consideration, the figures suggest confinement practices among pueblo women which were extremely detrimental to the safety of the child, but which were modified in the last quarter of the nineteenth century.

[21] S. B. D. Aberle. Child mortality among Pueblo Indians. *Amer. Jr. Phys. Anthropol.*, Vol. 16:3, 1932, p. 339.

D. Mortality of 1790 population

The incompleteness of the death records offered little promise of success in applying the usual direct methods of mortality analysis to them. Consequently, a special procedure was attempted, that of matching records of death against those of birth in earlier years. This method was not wholly successful because of difficulties with names. Infant deaths were most often identified. This resulted in too great an emphasis upon the population of the youngest age groups. It was also apparent that deaths of older persons were not always listed. In such cases it is possible that the church did not participate in the burial ceremony or the burials at home were not recorded.

It appeared, however, that better identification could be achieved if the time intervals during which names might have been altered were made as short as possible. This could be accomplished, at least to a certain degree, by making use of the 1790 census,[22] in which sufficient information was given for adult family members to permit checking against the death records. As these persons were nearly all over the age of twenty, the interval between the recording of their ages in 1790 and the date of death was considerably shorter than if birth records had been employed. Since names of children were not entered, only the designation *hijo* or *hija* (son or daughter) and the age could be used for identification. Consequently little could be done in establishing the age at death for those who were then under twenty years old.

TABLE 11

	OVER TWENTY YEARS OF AGE		
	Number on Census	Number Identified	Percent Identified
Pueblo	98	59	60
Outside Pueblo	556	155	28
Spanish	372	104	28
Indian and mixed	184	51	28
Unknown	8	0	0
Total	662	214	32.3

[22] See Section 2. Population:—under "Trends of total population".

Of a total of 1,534 recorded in the census, only 279 or 18.2 percent were identified. However, of the 662 known to be over twenty years of age, 214 or 32.3 percent were found on the death lists. These were classified according to race and residence (cf. Table 11).

Although but a few conclusions can be drawn from these samples, yet to the extent that they give a reliable picture of the population then existing, indications can be shown of mortality among persons over twenty years of age during the years that follow. Table 12 and Fig. 8 show the percentage distributions by age of the identified portions com-

TABLE 12

Age distribution of population of the 1790 total census and the identified portions

AGE	PUEBLO		OUTSIDE PUEBLO					
			Spanish		Indian & Mixed		Total	
	Census	Ident. Sample	Census	Ident. Sample	Census	Ident. Sample	Census	Ident. Sample
20-29	27	16	151	32	80	19	231	51
30-39	29	14	78	16	44	13	122	29
40-49	23	17	71	27	34	15	105	42
50-59	5	2	48	22	15	1	63	23
60-69	10	6	15	3	8	2	23	5
70-79	3	3	6	3	2	0	8	3
80-89	1	1	3	1	1	1	4	2
Total	98	59	372	104	184	51	556	155
			Percent					
20-29	28	27	40	31	43	37	42	33
30-39	30	24	21	15	24	26	22	19
40-49	23	29	19	26	19	29	19	27
50-59	5	3	13	21	8	2	11	15
60-69	10	10	4	3	4	4	4	3
70-79	3	5	2	3	1	0	1	2
80-89	1	2	1	1	1	2	1	1
Total	100	100	100	100	100	100	100	100

pared to those of the total census. These percentages indicate that for the pueblo the sample was fairly representative of the population as a whole, while for the non-pueblo population the sample was deficient at ages below forty years and in excess at older ages. An average age at death computed for each group as a whole would therefore not be accurate in describing the total Spanish mortality.

Distribution of the identified portions with respect to sex was not markedly different from those of the census when the relatively small numbers are considered. The greatest discrepancy was found for the Indian-mixed identified portion, which contained 51 percent males as

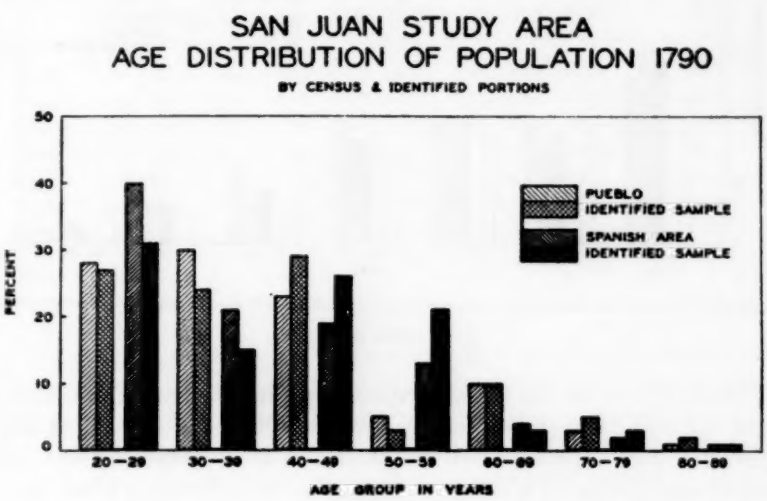

FIGURE 8

against 44 percent for the total Indian-mixed group. The identified portion from the pueblo showed 54 percent males as against 49 percent for the total pueblo census.

On the basis of the small numbers contained in these identified portions, only the most elementary interpretations were undertaken. A summary of the data is presented in Table 13, in which the mean years to death of the individuals falling within the specified age groups, was listed.[23]

[23] The value for the pueblo in the first line of the table indicates, for example, that the sixteen persons of the identified pueblo sample who were between 20 and 29 years in 1790 lived, on the average, 22.5 additional years; their mean age at

One can observe in Fig. 9 that the pueblo experience was such as to indicate a higher mortality than that found for the area outside the pueblo for all except the last age groups. The subdivision of the area outside into Spanish and Indian-mixed does not reveal any significant trend.

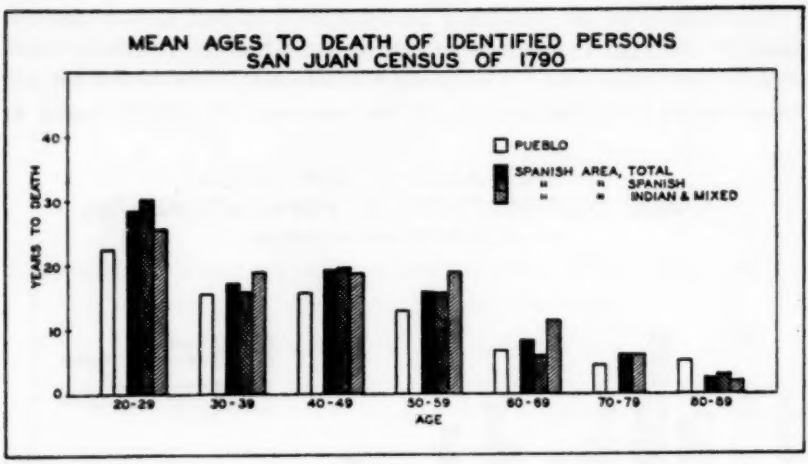

FIGURE 9

Considered as curves of life expectancy, the results indicate that a longer span of years was lived by those reaching the age of 40 than might have been expected from the decline in life experience from ages 20-29 to ages 30-39. It is difficult to conceive of a situation which gives rise to an excessive mortality at ages 30-39 over that of ages 20-29 and 40-49. Tuberculosis and syphilis have been suggested, but it is unlikely that these diseases strike harder in that particular age period than in the adjacent ones.

It is interesting to compare the indications of life expectancies shown in Table 13 with results obtained for other population in other times. Strictly comparable age periods to that of 20-29 years are not obtainable, so for Table 14 the age of 25, which is at the center of our span, has been employed.

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the time of census was 23.9 years. This value, 22.5, is roughly comparable to the expectation of life values of modern life tables if one keeps in mind that the present data are actual *experienced* years of life and not theoretical values derived from the mortality observed within any short span of time.

TABLE 13

Mean years to death, by broad age groups, of the identified portions of the 1790 Franciscan Census

AGE	PUEBLO			OUTSIDE PUEBLO								
				Spanish			Indian & Mixed			Total		
	No.	Mean Age at Census	Mean Years to Death	No.	Mean Age at Census	Mean Years to Death	No.	Mean Age at Census	Mean Years to Death	No.	Mean Age at Census	Mean Years to Death
20-29	16	23.9	22.5	32	24.6	30.2	19	24.1	25.7	51	24.4	28.5
30-39	14	34.1	15.6	16	34.6	16.1	13	34.6	18.9	29	34.6	17.3
40-49	17	43.4	15.8	27	44.2	19.7	15	43.2	18.7	42	43.9	19.3
50-59	2	55.0	13.0	22	54.6	15.9	1	50.0	19.0	23	54.4	16.0
60-69	6	66.2	6.7	3	63.7	6.0	2	61.0	11.5	5	62.6	8.2
70-79	3	70.7	4.3	3	71.3	6.0	0	.....	.....	3	71.3	6.0
80-89	1	87.0	5.0	1	83.0	3.0	1	80.0	2.0	2	81.5	2.5
Total	59			104			51			155		

The expectations of life given for Rome and Roman Egypt, about 2,000 years ago, are the only values given which approximate that of 22.5 years for the pueblo. No modern life table, not even the one for Breslau, Germany, in 1687-1691, gives as low an expectation at the age of 25 as that for the pueblo; the Breslau figure is similar to our own value for the Spanish area. The table also shows that life expectancy at the age of 25 changes slowly, as it increased only a few years in the United States during a thirty-year period which brought extensive environmental improvements and applications of preventive medicine. Therefore, the difference between the causal factors of mortality in the Southwest about 1800 and those of the United States today must be very great.

E. Mortality in recent years

For the study of mortality in San Juan Pueblo in recent years we are limited to the annual tabulations of the total number of deaths by age, since statements describing the cause of death are too incomplete to be acceptable, and the small numbers preclude subdivision by sex.

TABLE 14

Complete expectations of life at age 25

	PLACE	PERIOD	EXPECTATION OF LIFE AT 25 YEARS
1.	Rome	About 2000 years ago, males	19 approx.
	Rome	About 2000 years age, females	14 approx.
2.	Roman Egypt	About 2000 years ago	23 approx.
3.	Breslau, Germany	1687-1691	30
4.	U.S. Orig. Regis. States	1901	39
	U.S. Orig. Regis. States	1901, white males	39
	U.S. Orig. Regis. States	1901, white females	40
	U.S. Orig. Regis. States	1901, negro males	32
	U.S. Orig. Regis. States	1901, negro females	34
	U.S. Orig. Regis. States	1910, white males	39
	U.S. Orig. Regis. States	1910, white females	41
	U.S. Orig. Regis. States	1910, negro males	30
	U.S. Orig. Regis. States	1910, negro females	33
5.	Continental U.S.	1930, white males	41
	Continental U.S.	1930, white females	44
	Continental U.S.	1930, negro males	33
	Continental U.S.	1930, negro females	34
6.	Pueblo Indians	1790	22.5
	Spanish Area	1790	30.2

The number of deaths classified by broad age groups, for the twelve-year period 1925-1936, among the unadjusted population (1931) are given in Table 15. The corresponding rates with their respective standard errors[24] are also shown. The table is useful in indicating the small numbers involved and the wide chance variability of the death rates, rather than as an estimation of the actual mortality within the community. The enumeration of persons under the age of five was found to be incomplete; this fact together with the difficulty of obtaining accurate

[24] Computed from the formula:

$$\text{Standard error} = \sqrt{\frac{pq}{n}}$$

where p is the unit death rate, q its complement, and n the 1931 population of the group multiplied by 12.

TABLE 15

Deaths in the period 1925-1936 by broad age groups, with corresponding rates based on the 1931 unadjusted population

AGE PERIOD (*years*)	POPULATION 1931	DEATHS 1925-36, INCL.	ANNUAL AVERAGE DEATHS PER 1,000 POPULATION
Under 1	15	42	233 ± 32
1- 4.9	39	30	64 ± 11
5-14.9	124	3	2 ± 1
15-24.9	104	7	6 ± 2
25-44.9	130	9	6 ± 2
45-64.9	81	22	23 ± 5
65 and over	17	17	83 ± 19
Total	510	130	21.2 ± 1.8

and comparable mortality rates for the white population at large, prompted us to attempt the construction of a life table for the pueblo. However, the findings thus presented must be carefully interpreted in the light of fundamental data as given in Table 15.

The construction of the life table[25] was begun by making preliminary adjustments on the population data and the number of deaths to eliminate the minor irregularities. The population and death curves for persons over five years of age during the period stated were smoothed by means of sixth and seventh degree Gregory-Newton polynominals, respectively. The average rates of mortality (m_x) computed from the smoothed curves corresponded reasonably well to the mortality rates computed from the raw data.

The life table values are shown in Table 16 and on Figs. 10, 11, and 12. As a means of comparison, each chart also shows the curves for whites and negroes by sex in the United States Life Tables, 1930.

In the rate of mortality ($1{,}000q_x$) curves, Fig. 10, the chief difference between the pueblo and the groups with which it is compared is the tremendous mortality among the infants and young children of San

[25] The procedure followed was that presented in Chap. 14 of Length of Life by L. I. Dublin and A. J. Lotka. Ronald Press Co., *N. Y.*, 1936.

TABLE 16

Life table, San Juan Pueblo Indians, both sexes, 1925-1936

AGE	l_x	d_x	$1000\,q_x$	$\overset{0}{e}_x$
0	1000	174	173.7	43.2
1	826	80	96.9	51.2
2	746	34	45.5	55.6
3	712	10	13.8	57.2
4	702	4	6.5	57.0
5	698	3	4.3	56.4
6	695	2	3.5	55.6
7	693	1	3.2	54.8
12	692	5	0.2	49.9
17	687	17	3.7	45.2
22	670	23	6.8	41.2
27	647	22	7.3	37.7
32	625	17	5.2	33.9
37	608	17	5.2	29.8
42	591	28	7.4	25.6
47	563	45	13.3	21.7
52	518	64	22.0	18.3
57	454	74	31.7	15.5
62	380	75	40.1	13.1
67	305	65	46.6	10.7
72	240	67	50.8	7.9
77	173	92	96.9	5.0
82	81	67	228.8	2.8

Juan; proportionately twice as many deaths occurred as in the highest of the Negro or white groups. This high rate drops with age but does not approach the others until the fourth or fifth year. From about 15 to 70 years of age, the pueblo curve lies mainly between those of the whites and the Negroes; beyond 70 years it lies first below and then above the others, but no reliance can be placed upon the rate at these ages. A small peak in the pueblo curve occurs between the ages of twenty and thirty which may be attributed to the effect of tuberculosis upon the population of those ages.

The curve of survivors (Fig. 11) portrays the number of persons reaching each age interval out of 1,000 born alive. The effect of the high infant and childhood mortality in the pueblo is to leave only about

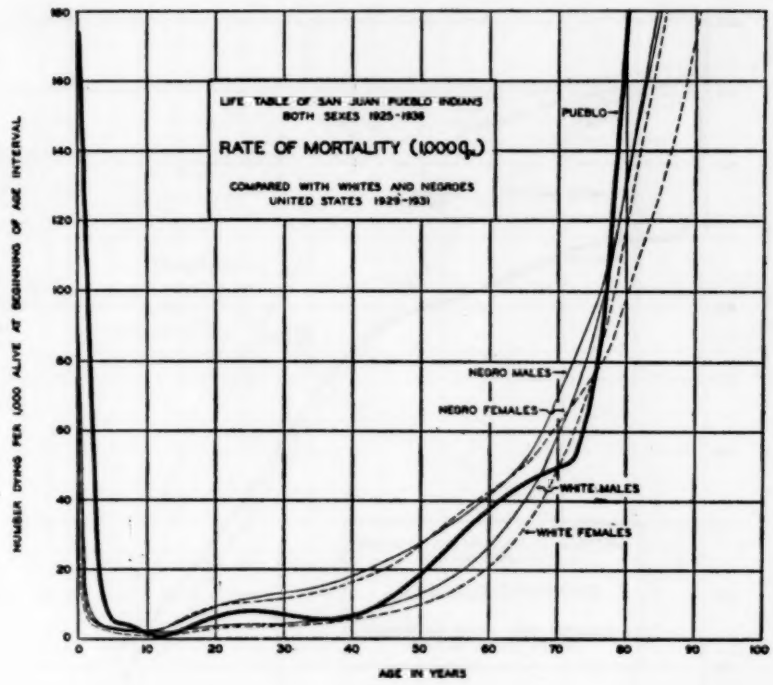

FIGURE 10

700 alive at the fourth year out of each original 1,000. The number of survivors continues to decrease steadily, but as the decline is less rapid, a larger percentage of the pueblo survivors remain after the fiftieth year than for the Negro groups. The curve for the whites is higher throughout; half the original thousand births are still alive at the 66th year of life, while among the San Juan Indians barely half remain at the 53rd year.

Perhaps the most interesting curve is that for the expectation of life. Fig. 12 shows that the expectation of life at birth in the pueblo is 43.2 years, as compared to 59.1 for white males, 62.7 for white females, 47.6 for Negro males, and 49.5 for Negro females. The pueblo curve rises rapidly to a peak of 57.2 years at the age of three; generally, throughout its course it is to be found in an intermediate position between those of the whites and those of the Negroes.

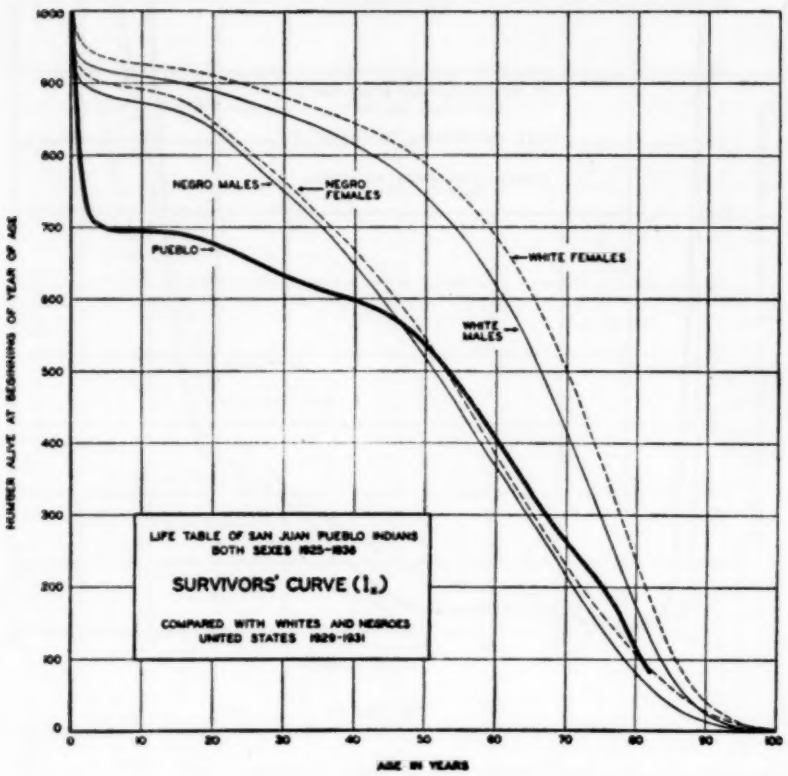

FIGURE 11

Compared with the life expectancy of 1790, as shown in Table 13, modern figures in the pueblo are considerably higher in ages from 20 to 30, with a gain of about 17 years. The older ages also show improvement.

Aside from the high mortality at the beginning of the life span, the San Juan Indians experienced a mortality somewhat higher than the white population in the United States as a whole, but lower than the Negroes. The present expectation of life at birth in the pueblo approximates that found for the population in the State of Massachusetts in 1890 (42.5 males, 44.5 females).

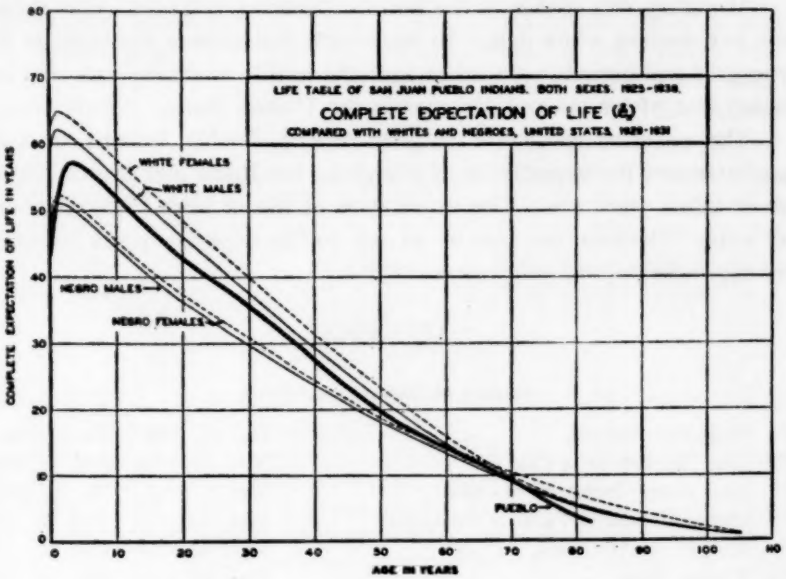

FIGURE 12

SUMMARY

Following a decrease of one-third of the population in 1781, the San Juan pueblo was found to have undergone three periods of growth: (1) a slow increase until 1850-60, (2) a stationery period, and (3) a rapid gain after 1905-10. The population increment since 1910 has been at the rate of 1.54 percent annually. The Spanish population showed no increase from 1800 to 1910, but has been growing since.

The proportion of pueblo males has increased during the last century. An epidemic had affected the data for 1790 so as to give small families and few persons between the ages of 5 and 25. Nevertheless, the median size of the pueblo family was slightly larger in 1790 (4.4) than in 1931 (3.8).

Compared with white ratios, plural births were low. Although fertility is now less than half the 1790 level, it is higher than for other races in the United States.

The growth in pueblo population has been caused by a decrease in in the death rate. The birth rate was lower in 1936 than it was in 1790.

Mortality was higher in the period following 1790 than that shown for any modern white data. In 1925-1936 deaths were excessive in the youngest age periods. At other ages the pueblo mortality rate was between that of whites and Negroes in the United States.

The expectation of life at birth among Pueblo Indians in 1790 approximates the expectation of life given for Rome and Roman Egypt about 2,000 years ago. The expectation of life at birth in 1925-36 was 43 years. Between the ages of 20 and 30 life expectancy has increased by approximately 17 years since 1790.

APPENDIX

PRIESTS OF SAN JUAN PARISH

Fr. Francisco Antonio	Jan. 26, 1726 – June 7, 1729
Fr. Juan Sanchez de la Cruz	Nov. 13, 1729 – Feb. 12, 1746
Fr. Juan Joseph Perez de Mirabel	Mar. 6, 1746 – Feb. 23, 1763
Fr. Joseph Eleutherio Tunco y Tunquera	Mar. 10, 1763 – Aug. 6, 1770
Fr. Manuel de Albadiano	Sept. 16, 1770 – Mar. 20, 1774
Fr. Ramon Salas	May 12, 1774 – Apr. 29, 1776
Fr. Jose Palacio	June 9, 1776 – Jan. 8, 1779
	Jan. 17, 1779 – Oct. 19, 1783
Fr. Santiago Fernandes Sierra	Sept. 5, 1784 – Jan. 7, 1787
	Sept. 8, 1787 – Feb. 14, 1793
Fr. Tomas Salvador Fernandes	Jan. 25, 1787 – Aug. 26, 1787
Fr. Gabriel de Lago	Feb. 21, 1793 – June 25, 1794
Fr. Jose Rubide Zelig	July 21, 1794 – Aug. 9, 1794
Fr. Ramon Antonio Gonzales	Nov. 27, 1783 – Aug. 8, 1784
	Aug. 26, 1794 – Mar. 17, 1815
Fr. Isidoro Barcevilla	Mar. 19, 1815 – June 23, 1816
Fr. Mariano Jose Sanchez Vergaro	July 14, 1816 – Apr. 24, 1820
	Jan. 30, 1823 – Nov. 24, 1823
Fr. Theodoro Alcina	Aug. 13, 1822 – Jan. 22, 1823
Fr. Manuel del Valle	Nov. 26, 1823 – July 18, 1826
Juan Felipe Ortiz	July 25, 1826 – May 18, 1828
Manuel de Jesus Rada (Santa Cruz)	June 2, 1828 – Sept. 10, 1828
Manual Murga	Sept. 16, 1828 – June 29, 1829
Jose de Castro	July 5, 1829 – Jan. 4, 1833
	Nov. 2, 1833 – Oct. 4, 1840
Fernando Ortiz	Jan. 6, 1833 – Oct. 6, 1833
	Jan. 10, 1846 – Dec. 18, 1854
Jose de Jesus Lujan	Nov. 22, 1840 – Apr. 13, 1841
Jose Manuel Gallegos	Apr. 14, 1841 – Oct. 8, 1845

Juan de Jesus Trujillo	Oct. 12, 1845 – Jan. 4, 1846
Antonio Jesus Salasar	Jan. 25, 1846 – Mar. 15, 1846
Jose Eulogio Ortiz	Dec. 12, 1854 – June 7, 1857
	Feb. 1, 1859 – Mar. 2, 1862
Ramon Medina	June 10, 1857 – Jan. 29, 1859
	Apr. 25, 1862 – June 24, 1862
Francisco Boucard	July 3, 1862 – Nov. 24, 1865
Pedro Lassigne	Dec. 12, 1865 – July 12, 1868
Camilo Seux	July 15, 1868 – Jan. 22, 1922
S. Alvernhe	Jan. 1, 1914 – May 4, 1923
Joseph Pajot	May 4, 1922 – present

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THE TREND IN THE PROPORTIONAL CONTRIBUTION OF THE SOCIO-ECONOMIC GROUPS TO NATALITY

A REPORT BASED ON THE BIRTHS IN WASHINGTON COUNTY, MD. FROM 1898 TO 1938*

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THE PROBLEM

SINCE the turn of the century demographers and other population students have increasingly directed their attention to the differences in the fertility of the social classes. The numerous investigations that, following the classical works of Bertillon and Heron, have been made on the subject all point to a higher average fertility in the less affluent social classes and a lower reproductivity in the well-to-do and professional groups. From a practical standpoint the phenomenon could have important consequences. Conceivably, and in view of the declining birth-rate, if the social differences in fertility are large and extend over a long period of time, the effects will be manifest in the social structure of the population and therefore in those aspects of health and well-being that are intimately associated with social and economic status. The realization that such consequences are possible has preoccupied those who are interested in formulating population policies for the future. Eugenists especially have been alarmed by the decline in birth-rate combined with the class differences in fertility, and lately some English writers (cf. Cattell, 1937) have gone so far as to predict the downfall of civilization as the

* This is the second of a series of papers entitled: Studies on the Biological Factors in Public Health. For the first, cf. Ciocco (1940).

result of this phenomenon. In reality, notwithstanding the hundreds of reports on the subject, the conglomerate knowledge so far acquired offers no factual basis for predictions concerning the future social composition of the population or the future of any other population characteristic that could possibly be the outcome of the class differences in reproductivity. In the first place, the relative size of the social groups into which a population can be segregated, depends not only on natality but also on migration and on the movement from class to class within the population. But most significant is the fact that since class differential fertility is to a great extent a function of the intelligent use of contraception, as Pearl (1939) has clearly shown, the existence of social differences today bespeaks little for the future. In this respect, the observations by Edin (1929) in Sweden, Notestein (1938) and Kiser (1939) in this country, and Innes (1938) in England are pertinent since they indicate that the rate of decline in the fertility of the less prosperous elements of the population is reducing the differences of the socio-economic groups. It is apparent that a more comprehensive description of the phenomenon is required before its future effects can be gauged with any degree of assurance.

Furthermore, any bearing that a class differential fertility may have on problems connected with the social composition of the population depends largely on the composition of the population at the time and on the factors responsible for class segregation. If, for example, a selected group reproduces itself at a lower or higher rate than the remainder of the population, the significance of this fact will increase directly with the numerical importance of the group in the population and with the multiplication of barriers that prevent the circulation of individuals of the group to and from the remainder of the population. It follows that, to determine whether the natural increment of the population due to natality has altered relative to socio-economic characteristics, a measure is required that expresses the combined effects of the differences in the fertility of social groups, of intra-class movements and of migration. As a contribution to this aspect of the problem of class differential fertility this paper presents data on the relative number of registered white births of Washington County, Md., that each year from 1898 to 1938 have been born to fathers who were (a) owners, managers, officials, and professional men, (b) skilled and semi-professional workers, and (c) unskilled and semi-skilled laborers.

MATERIAL

This study is based on the records of the white births registered in Washington County, Maryland, from 1898 to 1938 inclusive.[1] Since the year of 1898 marks the beginning of the present civil birth registration in the county, the records of this and immediately subsequent

TABLE 1

Crude birth rates for the white population of Washington County, Maryland, from 1898 to 1938

Calculated from the births registered in the Washington County Health Department.

YEAR	REGISTERED BIRTHS PER 1000 POPULATION	YEAR	REGISTERED BIRTHS PER 1000 POPULATION
1898	4.1	1918	25.7
1899	12.6	1919	24.0
1900	12.1	1920	26.9
1901	13.8	1921	25.7
1902	14.7	1922	24.9
1903	15.5	1923	24.5
1904	14.2	1924	24.2
1905	16.2	1925	24.3
1906	16.3	1926	23.9
1907	18.2	1927	22.5
1908	19.1	1928	22.6
1909	20.3	1929	19.6
1910	20.8	1930	20.4
1911	18.4	1931	20.2
1912	22.3	1932	18.4
1913	24.5	1933	17.8
1914	27.0	1934	17.7
1915	27.9	1935	17.5
1916	27.4	1936	16.5
1917	26.5	1937	18.0
		1938	17.3

[1] The author takes this occasion to express his thanks to Doctor R. W. Cameron, county medical officer, who kindly made the records available, and to Miss B. Cheney of Philadelphia and the Misses D. Newey and L. Rohrer of Hagerstown who in their various capacities were responsible for the transcription and tabulation of the material and assisted in the analysis.

years are far from complete. It is estimated by Doctor A. W. Hedrick, present chief of the bureau of vital statistics of the state of Maryland, that as late as 1910 only 65 per cent of the births were being registered. However, within the following decade this percentage had risen to 95 and at present is even slightly higher. The effects of the early incomplete registration and of the subsequent improvement are evident in the crude birth rates computed for the years 1898 to 1938 and presented in Table 1. According to the results shown in Table 1, it appears that in 1898 there were only 4.1 births per each 1000 white inhabitants. In the following year, the rate jumped to 12.6 per 1000 and from then on increased until a high of 27.9 per 1000 was reached in 1915. Thereafter a steady decline in the birth-rate has taken place.[2] The rate for 1898 is manifestly absurd and in view of what is known about natality since 1900 it is probable that the figures from 1899 to 1912-13 are too low.

A deficiency in registration may well affect the results of a study concerned with socio-economic classes. Presumably, births in hospitals or attended by physicians are those that with the greatest probability will be registered, and therefore, recalling the mores of the first part of the century, it is to be expected that the registered births from 1898 to about 1910 will be weighted in favor of the more well-to-do classes. For this reason, although all the data from 1898 to 1938 are presented, attention will be primarily focussed on the figures obtained for the years following 1910.

CLASSIFICATION OF OCCUPATIONAL STATUS OF FATHERS

The information recorded on the birth certificates regarding the occupation of the father has been utilized as the basis for the segregation of the births according to socio-economic level. To this end, the occupations have been classified into three broad categories: I. Owners, managers, officials, and professional men; II. Skilled and semi-professional workers; III. Laborers—unskilled and semi-skilled. As Pearl states:

> The underlying idea is to contrast *primarily* two groups of persons, namely those (I) who, on the whole, are situated at or near the top of things in the existing social organization, and those (III) who, by and large, find themselves at or near the bottom of the same social organization. This leaves a third class (II); persons who are, on the whole, neither very near the top nor the bottom,

[2] With regard to the demographic characteristics of Washington County, Maryland in comparison to those of Maryland and the United States, cf. Ciocco, 1940.

and who, if they are sometimes thought and sometimes think themselves to be worse off than those in class I, are plainly and admittedly better off, on the whole, than those in class III.

With the information given on the birth certificates, no difficulty was encountered in classifying the occupations into the specific groups except when "farmer" was recorded. Since under this heading are probably included farm laborers as well as farm owners, it has seemed wiser to consider them separately and add a new class, viz. "farmers," to the three mentioned above.

Data on the distribution of the male population of Washington County according to this classification are not available nor can they be derived from official census reports. However, some indication of the prevalence of each category may be deduced from the statistics on the occupations of the single white men residents of the County and who were married there during the years 1915 to 1937 (cf. Ciocco, 1940). These statistics, based on all the marriage records in which the occupation was stated are summarized in Table 2.

TABLE 2

Percentage distribution of white males according to the specified occupational categories

Data derived from the marriage certificates of the single men residents of Washington County, Maryland, and who were married there in the stated years.

YEAR OF MARRIAGE	PERCENT				TOTAL NUMBER OF MEN
	I Owners, managers, officials, and professional men	II Skilled and semi-professional workers	III Laborers—unskilled and semi-skilled	Farmers	
1915-17	6.5	41.5	27.4	24.6	833
1918-22	7.6	43.2	23.7	25.5	1144
1923-27	7.5	46.5	29.9	16.1	1170
1928-32	7.3	44.7	29.9	18.1	962
1933-37	5.9	47.1	29.4	17.6	1502
All years	6.9	44.9	28.1	20.1	5611

It is seen from Table 2 that from 1915 to 1937 almost one-half of the bridegrooms were stated to be skilled and semi-professional workers while only about 7 per cent belonged to Class I. Farmers represented a fifth of all the single white men who married and the unskilled workers constituted slightly over one-fourth. It is of great interest that, on the whole, during the 23 years from 1915 to 1937 no very marked or definite change has occurred in these proportions. Thus, it could be inferred that no striking alteration in the social composition of the population has occurred in this period. However, it should be noted that:

1. In the immediate post-war period, 1918-22, the percentages for Class II and III reached their respective lowest values and conversely those for Class I and for farmers acquired their highest.
2. Since 1918-22 the percentages for Class I and for farmers demonstrate a tendency to decline.

These appear not to be significant variations and probably result from the association between economic fluctuations and marriage rate but since they could affect the social composition of the births they deserve to be carefully considered in this study.

THE RELATIVE FREQUENCY OF BIRTHS ACCORDING TO THE OCCUPATIONAL STATUS OF THE FATHERS

From 1898 to 1938, 47,263 white births about whom there is information concerning the paternal occupational status have been registered in the Washington County Health Department. This number constitutes over 93 per cent of all the births, white and colored, recorded during this period in the county registers. Of the 47,263 births, 7.8 per cent occurred to fathers of occupational Class I (owners, managers, officials, and professional men); 38.2 per cent occurred to fathers of Class II (skilled and semi-professional workers); 32.3 per cent to fathers of Class III (unskilled and semi-skilled laborers); and 21.8 per cent to "farmers." As is known, this last group consists of farm owners and managers as well as farm laborers. Since it comprises elements of all three socio-economic classes there is no good reason for its inclusion in the comparison of the contribution made to natality by each of the socio-economic classes. By omitting this group the number of births are reduced to 36,971 of which 9.9 per cent occurred to fathers of Class I, 48.8 per cent to fathers of Class II and 41.3 per cent to fathers of

TABLE 3

Percentage of births according to occupational status of fathers, calculated for each quinquennium from 1898 to 1937. White births registered in Washington County, Maryland, 1898-1938

FIVE YEAR PERIOD CENTERING AT YEAR	OCCUPATIONAL CLASS OF FATHERS I	II	III	"Farmers"	TOTAL	NUMBER OF BIRTHS
	A. Per cent births, including "farmers"					
1900	10.8	29.2	33.6	26.5	100.1	2415
1905	8.2	33.3	36.6	21.9	100.0	3518
1910	8.0	35.9	34.4	21.7	100.0	4996
1915	7.2	39.3	32.6	20.9	100.0	7728
1920	6.5	39.5	30.5	23.5	100.0	7669
1925	7.1	39.9	32.9	20.1	100.0	7420
1930	8.4	40.1	30.8	20.7	100.0	6457
1935	8.4	37.9	32.1	21.7	100.1	5947
All years 1898-1938	7.8	38.2	32.3	21.8	100.1	47,263
	B. Per cent births, excluding "farmers"					
1900	14.6	39.7	45.7	....	100.0	1776
1905	10.5	42.7	46.8	....	100.0	2748
1910	10.3	45.9	43.9	....	100.1	3912
1915	9.1	49.7	41.2	....	100.0	6111
1920	8.5	51.7	39.9	....	100.1	5866
1925	8.9	49.9	41.2	....	100.0	5931
1930	10.5	50.6	38.8	....	99.9	5118
1935	10.7	48.4	41.0	....	100.1	4654
All years 1898-1938	9.9	48.8	41.3	....	100.0	36,971

Class III. The variations of these proportions from 1898 to 1938 are summarized in Table 3 and illustrated in Fig. 1.

In Fig. 1 are graphically presented the precentages contributed by each of the three classes to the total births for each year from 1898 to 1938 and for each quinquennium from 1898 to 1937. The latter percentages are also reported in Table 3B. In order to demonstrate clearly that by the exclusion of the "farmers" no perceptible alteration of the trends of the proportions of each class can be distinguished, the percen-

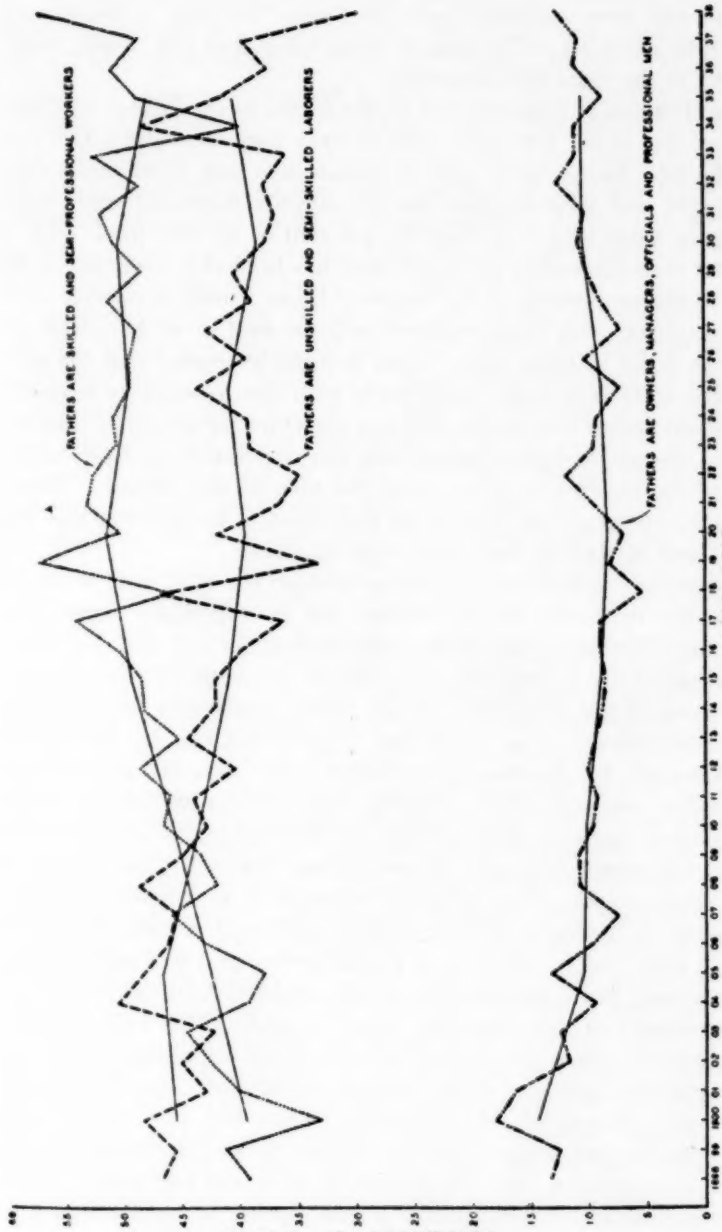
FATHERS ARE SKILLED AND SEMI-PROFESSIONAL WORKERS
FATHERS ARE UNSKILLED AND SEMI-SKILLED LABORERS
FATHERS ARE OWNERS, MANAGERS, OFFICIALS AND PROFESSIONAL MEN
PERCENTAGE OF BIRTHS
CALENDAR YEAR

FIG. 1. PERCENTAGES CONTRIBUTED BY EACH OF THE THREE STATED SOCIO-ECONOMIC CLASSES TO THE WHITE BIRTHS (EXCLUDING BIRTHS TO FARMERS) REGISTERED IN WASHINGTON COUNTY, MARYLAND, IN THE SINGLE YEARS FROM 1898 TO 1938. The solid lines represent the percentages for each quinquennium from 1898 to 1937 (cf. table 3B).

tages have also been calculated with the group "farmers" included and are shown in Table 3A. The data of Table 3B and of Fig. 1 will, however, serve as the basis for discussion.

If the attention is focussed first on the births to the fathers of Class I, it is seen that in the five years 1898 to 1902, they constituted 14.6 per cent of the total births, in the next quinquennium they represented only 10.5 per cent and their relative number steadily decreased until 1920 (1918-1922) when they comprised 8.5 per cent of all the births. After this period each succeeding quinquennium has been characterized by an increase in the proportion of the births of Class I until in the five year period, 1933-1937, this class produced 10.7 per cent of all the births or as much as it did in 1902-1907. Since it could be argued that the percentage for 1900 is probably abnormally high due to selective registration, it would follow that during the last ten years the group of owners, managers, officials, and professional men has contributed as much to the natality of the community as it did at the turn of the century. Moreover, if the percentage for 1938 is an indication, it would seem that the upward trend started in 1918-1922 may continue.

It is especially to be noted that the percentage for 1933-1937 is higher than that for 1918-1922 by an amount that is statistically significant. In turn, the difference between the latter percentage and that for 1903-1907 is significantly greater than expected on the basis of chance alone.

The trend in the proportion of the births contributed by Class III has different characteristics from that relative to Class I. In the ten years 1898-1907, the percentages of births from Class III assumed the highest values since observed. During 1903-1907, unskilled and semi-skilled laborers fathered 46.8 per cent of the total births of the period but in the subsequent ten years the percentage diminished, reaching 39.9 in 1920 (1917-1922). Thereafter, an increase to 41.2 percent in 1925 was followed by a drop to 38.8 per cent in 1930, and in turn, the period 1933-1937 exhibited a return to a higher level—41.0 per cent. From Fig. 1 it is seen that a marked drop in the proportion of the births that is due to fathers of this class took place in 1938. This fact, together with the data of Table 3 and of Fig. 1 gives the impression that after 1905 the unskilled and semi-skilled laborers have contributed in decreasing amount to the natality of the county. From Fig. 1, it is also to be observed that the percentages of births of this class exhibit a remarkable excursion from year to year. In particular, there are two peaks, one in 1918 and another in 1934 that probably have significance as consequences of temporary economic upheavals.

The pattern presented by the trend of the proportion of births contributed by skilled and semi-professional workers is almost the exact reverse of that observed for Class III. From 1900 to 1920 the percentages have risen steadily from 39.7 to 51.7. Subsequent to 1920 a level between 48 and 50 per cent has been maintained although a noticeable drop in 1935 brings the proportion lower than that seen in 1915. This dip is complemented by the peak observed in the case of Class III. However, an upward swing of the percentages after 1935 would seem to indicate that a tendency is present for Class II to increase its relative contribution to the natality of the community.

A comparative view of the direction and magnitude of the relative changes in the percentages of the births from each class for each quinquennium from 1898 to 1937 is obtained by translating the percentages to a uniform scale. This can be done by dividing the percentages for each quinquennium by the percentage for all the 41 years, 1898 to 1938, as given in the last row of Table 3B. Thus, the quinquennial percentages are transformed to index numbers having as a base the percentage for all the 41 years. Values above 100 indicate that the particular quinquennial percentage is higher than that for the whole period 1898 to 1938, values below 100 indicate the contrary. The results of this transformation are illustrated in Fig. 2.

The data of Fig. 2 brings out clearly the differences in the pattern of the trend for the three socio-economic classes. The index numbers for the proportion of births from Class I form a U-shaped curve, those relative to Class III, instead, result in something similar to a J-shaped distribution, while those from Class II form the reverse of the latter. The proportion of registered births contributed by Class I during the five year period, 1898-1902 was 45 per cent higher than that for all the years from 1898 to 1938. The bottom of the curve was reached in 1918-1922 when the proportion of births from Class I had fallen to only 85 per cent of the 41 year level. From 1920 commenced the rise in the relative frequency of births from Class I and the proportion for 1935 was over 7 per cent higher than that for the 41 year total.

The index number for the proportion of births from Class III is above 100 for the years prior to 1915 but consistently below for the years that follow 1915. This emphasizes the general decline in the proportional contribution of this occupational class to natality, a decline particularly marked from 1905, when the relative frequency of births from this class was 13 per cent higher than the 41 year total, to 1920 when it became 3 per cent lower.

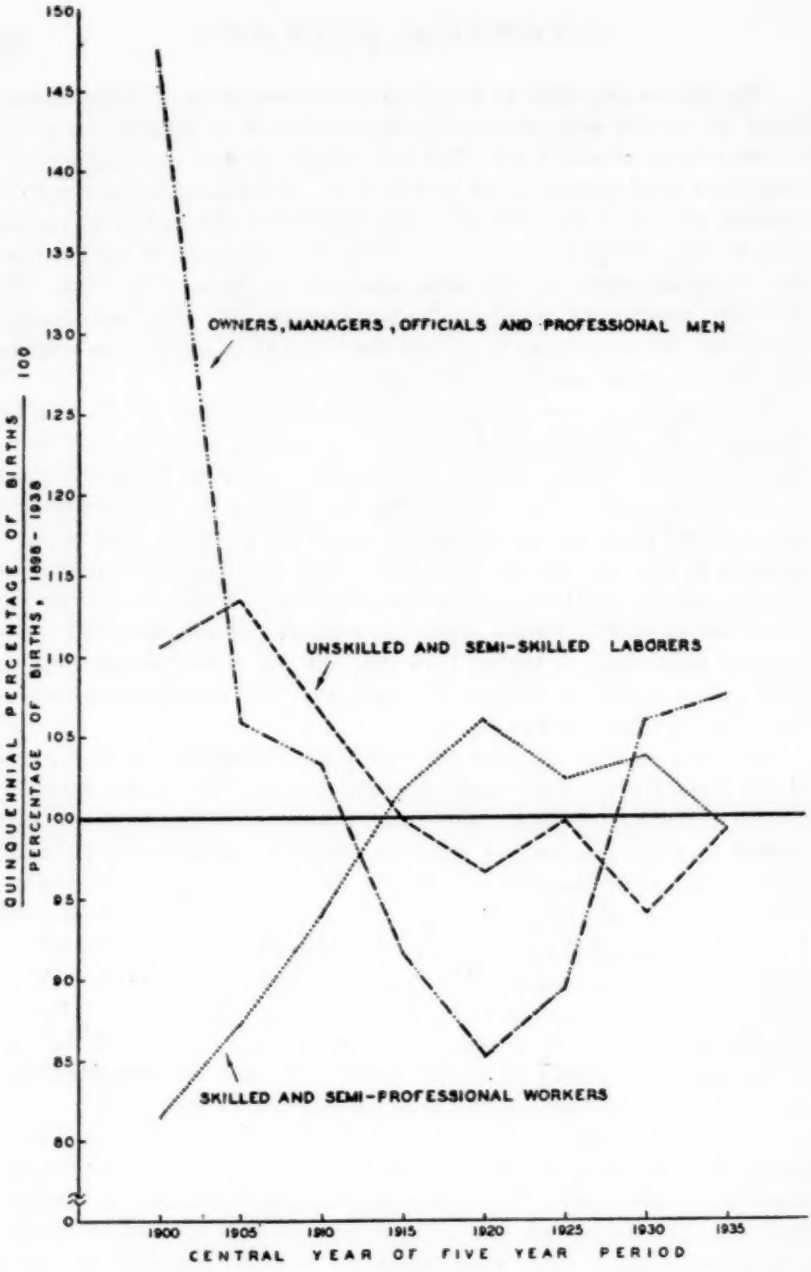

FIG. 2. COMPARATIVE TRENDS OF THE PERCENTILE CONTRIBUTION MADE BY THE RESPECTIVE SOCIO-ECONOMIC CLASSES TO THE BIRTHS IN EACH QUINQUENNIUM FROM 1898 TO 1937

The percentage for the total 41 year period 1898-1938 has been made equal to 100. Values above 100 indicate that the particular quinquennial percentage is higher than that for the whole period 1898 to 1938, values below 100 indicate the contrary.

The fact that the characteristics of the trend for Class II are almost the complete reverse of those of Class III for the periods up to 1915 are very apparent in Fig. 2. For Class II, the relative frequency in 1900 was 19 per cent lower than the 41 year total and it rose between 1900 and 1920 to a value of 6 per cent higher than that level. After 1915, the data of Fig. 2 indicate that the proportional contribution of Class II as well as of Class III, has remained at a more or less constant level but showing a tendency to decline. This is to be expected since Class I has increased its proportional contribution to the natality. From this study the main findings may then be summarized as follows:

1. The proportional contribution of owners, managers, officials, and professional men to the natality of the county decreased considerably from 1898 to 1920 but from this date to the present it has increased and has even surpassed the level of the years 1903 to 1907. In addition, it is important to realize that the proportion for 1917-1922 is statistically significantly lower than both that for 1903-1907 and that for 1933-1937.

2. The proportional contribution of skilled and semi-professional workers to the births increased from 1898 to 1915 and has maintained itself at the level reached with apparently a slight increase from 1936 to 1938.

3. The proportional contribution of unskilled and semi-skilled laborers to natality declined steadily until the year 1920 and then has changed little except for temporary movements obviously connected with economic upheavals and for a possible further decline from 1936 to 1938.

It may be that the social composition of the births have been affected by the incompleteness of the birth registration in the first years following 1898. However, the most significant aspects of these observations are the trends following 1915 when the birth registration in the county had practically reached its present level of completeness.

DISCUSSION

The present study was undertaken for the purpose of determining whether the social composition of the births of this county which contains both rural and urban elements has altered in the recent past, and if so, the direction of the change. The question uppermost in mind is whether the lower fertility of the well-to-do and professional persons is leading to a higher proportion of births from the poorer and less

favored social groups. From the analysis of these data on the population of Washington County, Maryland, it appears that a definite change has taken place, but not in the manner expected by some. From the begining of the century to about 20 years ago, a regular decrease in the relative number of births representing the highest socio-economic group is in fact observed and then, *ca.* 1920 the trend suddenly reversed itself. In the last few years as many children, relative to the total births of the community, are born to owners, managers, officials, and professional men as occurred in the beginning of the century. As an arithimetical consequence the proportional contribution of the other socio-economic groups to natality has decreased since 1920. In particular, the contribution of unskilled laborers seems to have declined substantially in the last years. Among the factors that could be postulated as the cause of this phenomenon, the principal are changes in (a) the social composition of the population and (b) the fertility of the socio-economic classes. There being no direct information on the socio-economic distribution of the population according to the criterion employed, it may be useful to

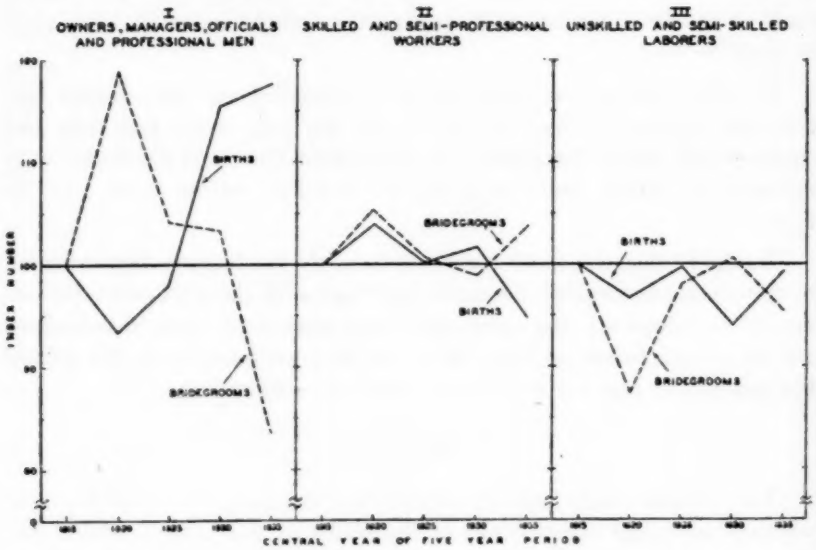

FIG. 3. COMPARISON OF THE TREND IN THE PERCENTAGES OF BIRTHS AND IN THE PERCENTAGES OF BRIDEGROOMS BELONGING TO EACH OF THE THREE SOCIO-ECONOMIC CLASSES

With regard to the births, the percentage for 1913-17 has been made equal to 100; in the case of the bridegrooms, the percentage for 1915-17 has been used as the base of the index number.

compare the above trends with those concerning the relative number of bridegrooms, never previously married, belonging to the three socio-economic classes. This comparison is illustrated in Fig. 3 in which are presented the index numbers of the percentage that each of the three socio-economic classes constitutes of (a) the bridegrooms (cf. Table 2) and (b) the births (cf. Table 3B) of each period. In the case of the bridegrooms, the percentage for 1915-1917 has been made equal to 100, in the case of the births, the index number is based on the percentage for 1913-1917.

The comparison made in Fig. 3 reveals that for none of the socio-economic classes is there a direct and consistent correspondence between the temporal variations in proportion that each forms of all the bridegrooms and all of the births respectively. In the case of Class II and Class III, peaks in the proportion of bridegrooms for 1920 are associated with peaks in the proportion of births for the same year but no such association is noted for the following years. It is to be particularly remarked that in the case of Class I the index number for the bridegrooms has decreased since 1920 while that for the births has increased. Therefore, if it is assumed that the proportion of bridegrooms from each class is an indication of the social composition of the whole population, the logical inference would be that the increased relative contribution of the highest socio-economic group to the natality of the community is not simply the result of an increase in the proportion of this class in the community.

If this inference is correct, then it follows that the phenomenon observed may be the consequences of (1) an increase in the fertility rate of the highest social group; or (2) a stable reproductivity in this class accompanied by a falling birth-rate in the other groups; or else (3) a declining fertility in all the social classes but more marked in the lower ones. Probative evidence to favor one or the other view is lacking but it is hoped that futher enlightment will be obtained from a study to be reported in a forthcoming paper relative to the trend in the age and parity characteristics of the mothers belonging to the three socio-economic classes.

In closing, the writer wishes to express his gratitude for the advise generously given by Doctor Raymond Pearl.

SUMMARY

A study on the white births registered in Washington County, Maryland from 1898 to 1938 reveals that of the total births, the percentage

belonging to the highest socio-economic class—owners, managers, officials, and professional men—decreased from 14.6 in 1898-1902 to 8.5 in 1918-1922. But, since 1920 this percentage has increased steadily and in the last years has returned to 10.7, a value higher than the level possessed in 1903-1907. This increase has been reflected in an alternating decline in the percentages observed for the births to skilled and semi-professional workers and to unskilled and semi-skilled laborers.

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THE PRENATAL DEVELOPMENT OF THE HAIR TRACTS IN PRIMATES

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PROBLEMS

HITHERTO no complete phylogenetic description of the hair tracts of the Primates has been published. Schwalbe (1910) gives in his work about the hair tracts of the Lemurs and of the Apes a description of the details of the species. His work is essentially systematic, and he compares the hair tracts of the head, the trunk, and the limbs of the different species. From the embryonic point of view the hair tracts should be related to the homologous structures of the body. Instead of comparing the hair tracts of the head or of the face, the comparison should be related to those of the areas of the middle nasal process, of the maxilla, of the mandible, etc.; or, as the pinna, to the hair tracts of the three mandibular hillocks and those of the three hyoid hillocks.

In this study there is presented for the first time a comparison of the hair tracts of the embryonic areas of these homologous structures and the descriptions of the hair tracts of the foetal pinna of the Anthropoids. Besides the phylogenetic descriptions, the present contribution deals with the problems of typology and constitution which the author has discussed in his previous communications (1925, '31, '38). The basic philosophy of the author's book *Grundzüge einer Konstitutionsanatomie* (1931) is synthetic rather than analytic, and the typological principle in that work puts the organisms on a common biological base, instead of separating them. Each homologous structure has its own time curves of determination, of growth, and of differentiation. Concerning the hair tracts, it may be likely that those of certain homologous areas have their own time curve so that a certain type of differentiation may appear very early in the course of the phylo-

genetic development, e.g. in the Lemurine stock, and may persist more or less in other orders of the Primates. Another type of differentiation may develop very late and become restricted to the Anthropoids only.

In 1926, Bolk gave the first description of the hair tracts of the Chimpanzee foetus and compared them with those of the Gorilla foetus. Although the Chimpanzee foetus which Bolk describes has a vertex-anus length measuring along the back of 24 cm. and is 2 cm. longer than the foetus which I examined, Bolk describes its hairs as so short that it seemed to be naked and in some parts the hairs were absent altogether, e.g. in the subumbilical area. The Chimpanzee foetus which I examined, however, had a well-developed haircoat and, consequently, my description of the hair tracts of some areas, e.g. the subumbilical area, is the first to be published. The Gorilla foetuses described in the literature comprise the following: Duckworth (1904), 7 cm.; A. H. Schultz (1927), 8.5 cm.; Deniker (1885), 13 cm.; Bolk (1926), vertex-coccyx 17 cm. The Gorilla foetus of this communication has a vertex-coccyx length of 24.4 cm. and is the oldest foetus so far described. It is noteworthy that the Gorilla foetus which Bolk examined and that of the present paper are males while the Chimpanzee foetuses are both females, so that any difference in the arrangement of the hair tracts cannot be attributed to sexual factors. The studies of A. H. Schultz on *Colobus* foetuses (1924), the Orang Utan (1933), the Chimpanzee foetuses (1933), and the Rhesus monkey (1937) contain many important contributions to the problems of the hair tracts which will be mentioned in the course of the description.

In what follows only new and important features will be described.*

MATERIAL

The specimens on which the following account is based consist of 14 foetuses, as follows:

(1) Three Lemuroids: *Chiromys madagascariensis*; *Loris lydekkerianus* (two specimens).

(2) One Tarsioid: *Tarsius spectrum.*

(3) Two Platyrrhines: *Cebus fatuellus (apella); Pithecia.*

* Abbreviation: L.G.F.=London Gorilla Foetus (the foetus I have examined); A.G.F.=Amsterdam Gorilla Foetus (the foetus Bolk has examined); L.Ch.F.=London Chimpanzee Foetus (the foetus I have examined); A.Ch.F.=Amsterdam Chimpanzee Foetus (the foetus Bolk has examined).

(4) Five Catarrhines: *Macaca mulatta, Macaca irus, Cercopithecus cynosurus, Cercopithecus grayi, Cercopithecus cephus*

(5) Three Anthropoids: *Hylobates,* Chimpanzee, and Gorilla.

For comparative purposes a new born Chimpanzee was examined.

THE HAIR TRACTS OF THE HOMOLOGOUS STRUCTURES OF THE FACE

1. Fronto-nasal area

The fronto-nasal area includes the parts of the face developed on the base of the embryonic fronto-nasal process, i.e. the hair tracts of the nose, the forehead up to the vertex, the upper lid, and the median part of the upper lip.

Chiromys madagascariensis: In 1922, J. P. Hill and R. H. Burne published an account of the foetal membranes and placentation of *Chiromys madagascariensis,* to which Pocock has since added an account of the external features including a general description of the hair tracts. I should like to add a few further details and also draw attention to the peculiarities of the hair tracts of the homologous structures.

The back of the nose is characterized by a median line of convergence to which converge the medially- and upward-directed hairs from both sides of the nose and also the upward- and medially-converging hairs of the tip of the nose. The nasal septum is continued into the philtrum which forms the medial part of the upper lip quite distinctly separated by a slit from the lateral maxillary parts of the upper lip. The septum and the philtrum are hairless, and the adjacent lateral parts of the upper lip have their own hair tracts. In *Loris* the areas in question are hairless.

Tarsius. The crown-rump length of the male specimen is 52 mm., so that the specimen is 11 mm. shorter than the female specimen described by Schwalbe. The long-haired tuft of the forehead and the short-haired tuft above the tip of the nose are joined by a median line of convergence at the back of the nose. The tuft of the forehead is caused by the hairs of the vertex directed forwards, which sweep from the whorl of the back, and the upward-directed hairs of the median line of convergence of the back of the nose. On the tip of the nose is the nasal tuft to which converge from below the upward-directed hairs of the dorsal part of the whorl on the median part of the upper lip. The laterally-directed hair tracts, which proceed from

the diverging centre of the medial angle of the eyelid, cover the upper lid of the eye and form, above the lateral angle of the eyelid, a line of convergence to which converge from behind the forward-directed hairs of the lateral parts of the scalp. At the level of the boundary between the fronto-nasal and maxillary areas are the diverging centres of the medial angle of the eyelid and of the nostrils.

Cebus apella. Along the middle line of the nose is a median line of convergence which, at the interocular level, are long black hairs arranged one above the other. The upper eyelid is hairless while the lateral parts of the eyelashes consist of long hairs directed downwards and outwards.

Pithecia. The back of the nose is hairless. On the medial area of the upper lip are some short hairs directed downwards. The eyelashes consist of very thin black hairs and are directed downwards on the border of the upper lid. The short hairs on the upper eyelid are well marked and pass upwards and outwards.

Macaca mulatta. The nose and the adjacent skin have only a hair coat of very short hairs directed downwards. The upper eyelid is hairless, and the black eyelashes of the upper lid are longer and thicker than those of the lower eyelid and directed upwards. The hairs of the median part of the upper lip pass upwards.

Macaca irus. The fronto-nasal hair tracts consist of thin, short, downward-directed hairs of the nose and upward-directed hair tracts of the median part of the upper lip.

Cercopithecus cynosurus. The hair tracts of *cynosurus* and *cephus* are very similar. The most noticeable difference is the median line of convergence of the forehead in *cynosurus* which forms a comb of 30 mm. length upwards from the glabella. The second difference between *cynosurus* and *cephus* is the well-marked radiating whorl on the place of the supra-orbital sinus hairs in *cynosurus*. The long hairs on the medial part of the upper lip are directed downwards.

Chimpanzee and Gorilla. The nose in the L.G.F. seems to be hairless, but by means of the binocular microscope and obliquely-directed electric light, one sees, on the borders of the nostrils and on the lateral parts of the nose, very short, thin, colorless hairs arranged sagittally. The shortest hairs of all are on the medial part of the back of the nose, and are continued on the adjacent skin of the cheeks. In the L.Ch.F. the back of the nose to the level of the sulcus interorbitalis, the tip of

the nose, the septum, and the paranasal area are all hairless. The borders of the nostrils also have very short, sagittally-arranged, colorless hairs. The two areas of the upper lip are well marked in the L.G.F. (Fig. 1). The median area consists of a 4 mm. broad ridge from the septum to the margin of the lip, on which are visible some isolated, short, stiff hairs. These hairs are sagittally implanted, one above the other. The lowest part of this intermaxillary area has some very short hairs along side one another and directed upwards. Instead

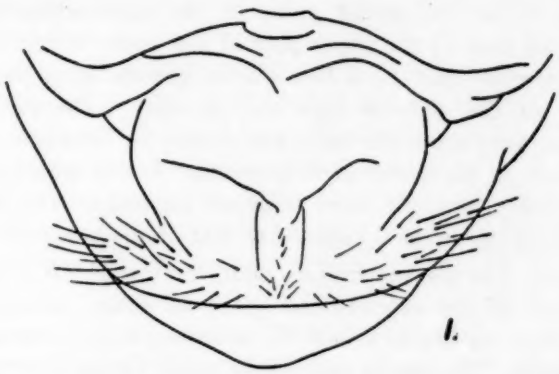

FIG. 1. UPPER LIP OF GORILLA FOETUS TO SHOW THE HAIR TRACTS ON THE MEDIAL AREA (PHILTRUM) AND ON THE LATERAL PARTS

of the groove of the intermaxillary area found in the human foetus, a ridge has arisen in the Gorilla foetus. In the small field between the median and lateral parts of the upper lip a few sagittally-arranged hairs are visible. About the A.Ch.F., Bolk did not give any description. In the L.Ch.F., the hairs of the medial parts of the upper lip, which are adjacent to the slit of the mouth, are very short and are arranged sagittally and directed slightly downwards. In the Orang Utan foetus, there is a bare area in the middle of the upper lip (A. H. Schultz, 1937). On the superciliary arch of the L.Ch.F., two areas, a medial and a lateral, are distinguishable. The medial area corresponds to the site of the supra-orbital sinus hairs and consists of fifty long, stretched, black hairs, of which the medial portion is directed upwards, and the lateral portion directed obliquely outwards. The lateral area of the eyebrows consists of twenty-five long, straight, black hairs directed outwards and downwards. The Gorilla foetus has also the

medial supra-orbital area as in the Chimpanzee. About twenty-five hairs of 30 mm. length are directed laterally and downwards. This field occupies about one third of the eyebrow region.

While in the Chimpanzee foetus the hairs of the lateral part of the eyebrows are directed downward and laterally, those in the Gorilla foetus follow the bow of the superciliary arch and cannot be separated from the hairs of the scalp. The eyelids of the L.Ch.F. are covered with very short, thin, black hairs which are directed upwards and outwards, following the same direction as the hairs on the forehead immediately below the medial group of the supra-orbital sinus-hairs. On the lateral area of the upper part of the eyelid which is separated from the principal part by a bow-shaped groove, some isolated long, black hairs of the eyebrow type can be seen. The eyelids of the L. G. F. have very short thin hairs visible only by binocular microscope, which proceed on the lateral parts outwards. In the middle area of the eyelids are some very thin hairs arranged sagittally. The direction of the hairs of the upper lid is opposite to that of the lower lid.

Hylobates. On the superciliary arch, the medial fifth, with the diverging whorl of the supra-orbital group of sinus hairs, can be distinguished from the lateral four-fifths with long hairs directed outwards and downwards. The medial part of the upper lip has densely-arranged hairs which are short and directed downwards.

2. Maxillary area

The maxillary area includes the parts of the face developed on the base of the embryonic maxillary process, i.e. the hair tracts of the cheek, the lower eyelid, and the lateral parts of the upper lip.

Loris. The lower eyelids, the anterior parts of the cheek adjacent to the nose beyond the zygoma are covered with hairs directed laterally and slightly downwards. The line of convergence of the cheek passes from the level of the lateral angle of the mouth upwards and rises in a tuft at the level of the lateral angle of the eyes. It is continued into the converging line of the lateral part of the forehead. The hairs of the upper lip are arranged in two rows—the upper, directed laterally, and the lower, near the margin of the lip, directed downwards.

Chiromys. The hair tracts of the upper lid of the eye form an arch with convexity directed upwards, those of the lower lid an arch with convexity directed downwards. Lateral to the angle of the eye-

lids, at a distance of 10 mm. directed upwards and outwards is a converging line corresponding to the boundary between the fronto-nasal and maxillary process at the side of the forehead.

Tarsius. At the boundary between the nose and the maxillary area is a diverging line. At its upper end is the diverging centre of the medial angle of the eyelid; at its lower end, the diverging centre of the nostrils. The hairs of the latter pass partly upwards and medially, partly laterally and transversely, and are very remarkable for their length and black color. The hairs of the lower lid and of the anterior part of the cheek are much shorter and directed transversely backwards. They end at the converging line of the cheek: the hairs near this line are directed upwards. The level of this converging line is between the lateral edge of the mouth and the converging centre of the lateral angle of the eyelid. On the medial part of the upper lip, which takes its origin from the fronto-nasal process, is a diverging whorl from which the hairs sweep upwards to the nasal whorl and downwards to the free border of the upper lip, while the hair tracts on the lateral parts of the upper lip proceed obliquely outwards.

Cebus apella. While the upper lid is hairless, the lower lid has short laterally-directed hairs forming the uppermost part of the long black hairs directed laterally and downwards on the area of the zygoma. On the anterior part of the cheek the hairs are long, white and black intermingled, and are directed backwards, forming the anterior part of the line of convergence of the cheek. The upper lip has a small channel and a notch on its lower border. The hairs of the medial part of the upper lip surrounding this channel are directed downwards, those of the lateral parts, outwards and downwards.

Pithecia. The hairs of the lower lid and on the cheek are laterally and obliquely directed downwards and form the anterior part of the line of convergence of the cheek. This line sweeps vertically downwards from the level of the temples to the level of the lateral angle of the mouth. The long hairs on the lateral parts of the upper lip are directed outwards and downwards.

Macaca mulatta. The most typical feature of the arrangement of the hair tracts is the whorl on the cheek. This whorl turns anticlockwise on the right cheek and clockwise on the left cheek. The line of convergence of the cheek sweeps from the level of the lateral angle of the mouth obliquely upwards. While in Lemur the upper end of this line is at

the level of the lateral angle of the eye, in *Macacus* this top is not reached but the hair tracts of the temples, directed downwards, push this top of the converging line backwards, so that a spiral whorl is the result. The hair tracts on the anterior part of the cheek proceed transversely backwards.

Cercopithecus cynosurus. The horizontal level of the diverging line of the cheek from which the hairs of the cheek sweep upwards and downwards is on the zygomatic arch. The long hairs on the lateral parts of the upper lip are directed laterally and slightly downwards.

Macaca irus. The line of convergence of the cheek is directed upwards. The anterior portion of this hair tract sweeps from the lateral parts of the lower lip, the anterior part of the cheek and the infrapalpebral area: the posterior portion sweeps from the mandibular angle. The line extends from the level of the lateral angle of the mouth to the level of the lateral angle of the eye. The hairs in front of the pinna and behind this line sweep upwards to the scalp and join the backward-directed hairs of the scalp. The hairs on the medial part of the lip are directed downwards, on the lateral part, outwards.

Chimpanzee and Gorilla. The hairs on the lateral maxillary parts of the upper lip of the L.G.F. cross each other, essentially in the medial parts, as some hairs proceed from below upwards and others from above downwards. The length of the hairs increases more and more on the lateral parts, so that the longest hairs directed outwards and downwards are above the lateral edge of the mouth. The convexity of most of the hairs is directed upwards. The isolated hairs on the lateral parts of the upper lip of the L.Ch.F. are directed outwards and downwards. The longest colorless hairs of this part near the lateral edge of the mouth are about 8 mm. long, and intermingled with four black stiff sinus hairs. At the middle vertical line of the cheek in the Chimpanzee foetus is a converging line formed by the pre-auricular and the anterior hair tracts of the cheek. Schwalbe and A. H. Schultz describe in the Orang foetus a crest in front of the ear where two streams of hair are directed against each other. In the Gorilla foetus, the lateral long hairs of the scalp are continued to the cheeks, sweeping downwards and obliquely forwards. Immediately behind the lateral angle of the mouth a small converging line may be seen formed by the above-mentioned hairs directed obliquely forward, and some hairs directed backwards proceeding from the folds of the anterior part of the face.

Hylobates. The lateral parts of the upper lip have long hairs directed outwards and downwards.

3. *Mandibular area*

The mandibular area includes the homologous structures developed on the base of the first visceral arch, i.e. the hair tracts of the right and left halves of the mandible, the chin and the three mandibular hillocks of the pinna and the pre-auricular area. The description of the hair tracts of the mandibular hillocks will be given in the section dealing with the pinna.

Loris. The pre-auricular area of the face has well-marked hair tracts directed forwards which end at the line of convergence of the cheek. These hair tracts continue those of the lower jaw which are directed backwards and upwards. The hairs at the margin of the upper lip are directed downwards and those of the lower lip run upwards and backwards. The chin has hairs directed downwards, and on both sides of the medial vertical line, hairs directed outwards.

Tarsius. On the mandibular area one can distinguish three hair tracts: (1) The long chestnut-brown hairs which sweep from the back part of the skull, proceed below the pinna forwards and end at a small distance behind the lateral angle of the mouth. (2) The short black hairs on the temples converging obliquely upwards from behind to the converging centre of the lateral angle of the eyelid. The opposite hair stream is the continuation of the hair tracts on the lower lid and on the cheek. (3) The median whorl of the lower lip from which white hairs radiate outwards in all directions. The lateral parts of the lower lip, the skin around the lateral angle of the mouth and of the submental area are hairless.

Cebus. The hair tract on the pre-auricular area sweeps from the mandibular angle and consists of long hairs. The stream is directed forwards and upwards. The lower forward-directed part of this hair tract forms the back part of the line of convergence of the cheek; its upper part proceeds to the area of the temples and to the lateral part of the scalp where it joins a spiral which turns backwards. The hairs on the lower lip are directed outwards.

Pithecia. The pre-auricular area has forward-directed hair tracts which are bounded above and below by the forward-directed hair streams which sweep from the area of the occiput and then proceed

forwards above and below the pinna. These hair tracts form the back part of the line of convergence of the cheek. The chin has long white hairs directed downwards and outwards, which sweep from a diverging centre on the middle of the lower lip.

Macaca. The pre-auricular area of the cheek is covered with downward-directed hairs. The most posterior part of this hair stream ends at the lower border of the pinna, turns backwards and forms at its end a sub-auricular converging line together with the hairs which pass forwards from behind the pinna. The most anterior portion of this hair stream proceeds downwards behind the whorl of the cheek and turns at its end obliquely forwards. Between these two ends is a quadrangular hairless area, bounded below by the two diverging ends of the upward-directed hair tract of the neck.

The chin has a diverging whorl. The hairs on the lower lip are directed outwards and laterally. The submental area has a median line of divergence formed by hairs which sweep from back to front. At the anterior end of this line is a quadrangular hairless area, of which the anterior ends are formed by hairs which proceed from the border of the mandible backwards.

Cercopithecus cynosurus. At the end of the line of convergence of the cheek in front of the root of the pinna there can be seen a small stream of hairs directed upwards. On the middle of the chin is a diverging star of long hairs and at both sides of it short hairs directed downwards and laterally.

Cercopithecus cephus. The hairs of the chin are directed downwards. The hairs in front of the pinna run in opposite directions, some upwards and others obliquely downwards, to the angle and the border of the mandible.

Chimpanzee and Gorilla. The chin of the Chimpanzee foetus has long colorless hairs which are 8 mm. in length. In the Gorilla foetus the hairs on the chin and the submental area converge to a tuft. The longest converging hairs are more than an inch in length. The submental area of the Chimpanzee has a line of convergence and a tuft.

Hylobates. The chin has long hairs directed downwards.

HAIR TRACTS OF THE SCALP, NECK, AND BACK

Loris (Fig 2). The hairs on the back part of the head are directed upwards and sweep from the right and left diverging whorls at the

level of the upper part of the back. On the bregma there is a median converging point and on the sagittal suture there is a converging line. All hairs of the back proceed from the above-mentioned whorls and are directed downwards. Between the whorls on the dorsal middle line a tuft is formed. The hairs adjacent to the middle line of the back converge to it and are directed downwards.

Chiromys (Fig. 3). *Chiromys* possesses the most primitive arrangements of the hair tracts of all Lemurs yet described. The slope

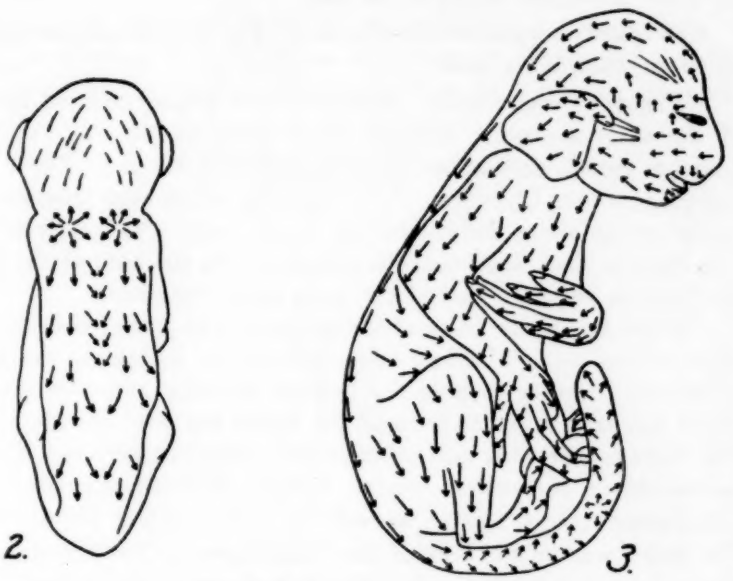

FIG. 2. BACK OF LORIS LYDEKKERIANUS FOETUS
FIG. 3. RIGHT SIDE OF CHIROMYS FOETUS

is from the forehead caudally across the vertex, neck, back to the root of the tail, as in other mammals (Schwalbe, Kidd).

Tarsius. The hairs of the scalp sweep out from a single median whorl on the back at the level of the upper end of the scapula and proceed across the middle of the occiput upwards to the tuft of the forehead. The hairs of the back are directed downwards and sweep outwards from the above-mentioned whorl.

Cebus. The hair tracts on the scalp proceed from the front towards the back across the vertex and form a converging tuft on the back

part of the neck. On the upper parts of the back the hairs converge to the medial-converging line.

Pithecia. The most noticeable feature is a whorl on the back, at the level of the upper end of the scapula from which the hair tracts sweep upwards across the occiput and the vertex. The hair tracts of the back proceed from the above-mentioned diverging whorl and sweep downwards.

Macaca mul. and *m. irus.* The hair tracts of the scalp sweep from the front across the vertex to the back.

Cercopithecus cynosurus and cephus. The hair tracts proceed from the front towards the back.

Chimpanzee and Gorilla. The shape and arrangement of the hairs of the scalp are quite different from those of the A.Ch.F. Bolk describes curled, dark-brown hairs implanted as bundles. The L.Ch.F. and the new born Chimpanzee have a parting which runs from the front to the vertex above the middle line of the scalp. The color of these long hairs is black, their shape is stretched. At the level of the vertex, the hairs on the back part of the scalp sweep backwards.

On the L.G.F. the hairs of the scalp are also arranged in the form of a parting, but the light median field in the middle of the parting is distinctly shorter than in the former specimen and it is restricted to the forehead, while in front of the vertex this field has disappeared. The hairs on the back part of the scalp sweep caudally and obliquely backwards on both sides. A. H. Schultz describes a parting in the Chimpanzee foetus (1933) as well as in the Orang foetus (1933). The hair tracts on the neck of the Chimpanzee are continued by those of the back part of the scalp. The hair tracts of the occiput proceed caudally across the back area of the neck. From this point the hair tracts turn laterally to both sides of the neck and proceed forwards more and more transversely arranged. On the front of the neck they form a median line of convergence of the neck, at the lower end of which the hairs slightly converge downwards to the front of the sternum. At the lower end of the median line of convergence a hairless jugular triangle is formed. The site of this jugular triangle corresponds to the site of the "sternal cross" in *Macacus,* described by Schwalbe. Also in the Gorilla foetus the arrangement of the hair tracts on the neck is the same as in the Chimpanzee. The jugular triangle can also be seen. Bolk describes the hairs of the neck as sagittally implanted and cau-

dally directed, but in both these anthropoids the direction of the hairs on the neck is transverse, forming a line of convergence on the front of the neck from back to front. A caudal direction of the hair tracts can only be seen in the median area of the back of the neck. On the back the hairs proceed downwards.

Hylobates. The hairs of the scalp pass from the front, backwards, and those on the back sweep downwards.

THE HAIR TRACTS OF THE LIMBS

As regards the hair tracts of the limbs the description may be restricted to those of the forearm only because they reveal a noticeable change of the type of differentiation in the course of the phylo-

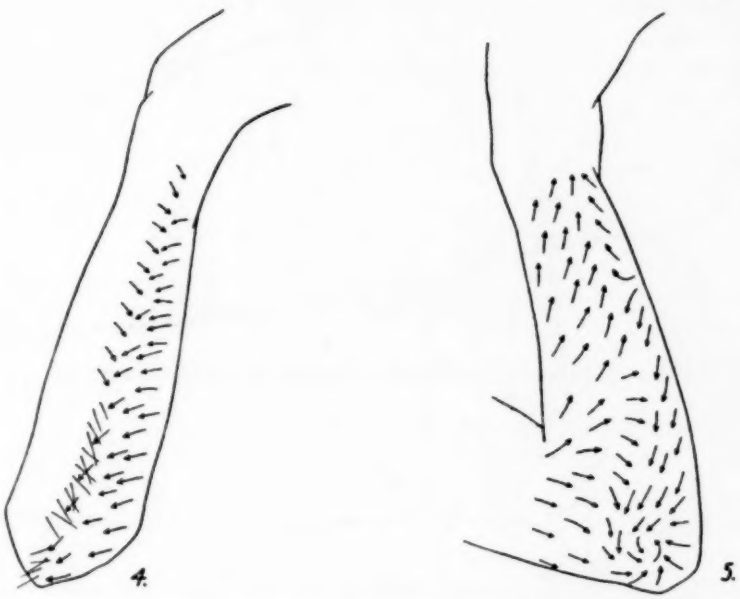

FIG. 4. ULNAR BORDER OF RIGHT FOREARM OF CEBUS FATUELLUS FOETUS
FIG. 5. ULNAR BORDER OF RIGHT FOREARM OF MACACA MULATTA FOETUS

genetic development. The hair tracts on the forearm in *Chiromys* preserve some primitive features while *Loris* has a more complicated arrangement. The long, chestnut-brown, densely-arranged hairs on the lateral surface of the forearm sweep obliquely from the radial

to the ulnar border. Therefore the ulnar border represents a line of convergence and the radial border a line of divergence as in other classes of mammals. *Loris* possesses, besides this feature, a whorl on the styloid process of the radius. That styloid whorl persists during phylogenetic development up to man. In the higher groups of the phylogenetic order the whorl becomes a starting point for the hair tracts of the ulnar border of the forearm. The whorl of *Loris*, however, has no relation to the surrounding hair tracts, especially those of the ulnar border, as it has in the anthropoids. In *Chiromys* and

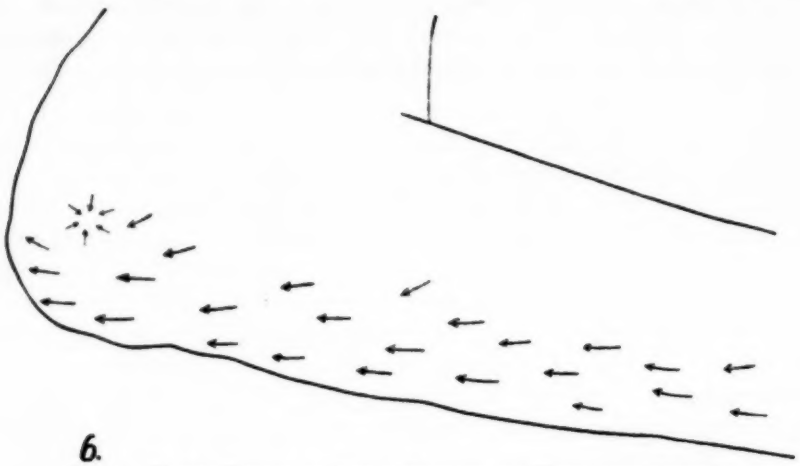

FIG. 6. ULNAR BORDER OF RIGHT FOREARM OF HYLOBATES FOETUS

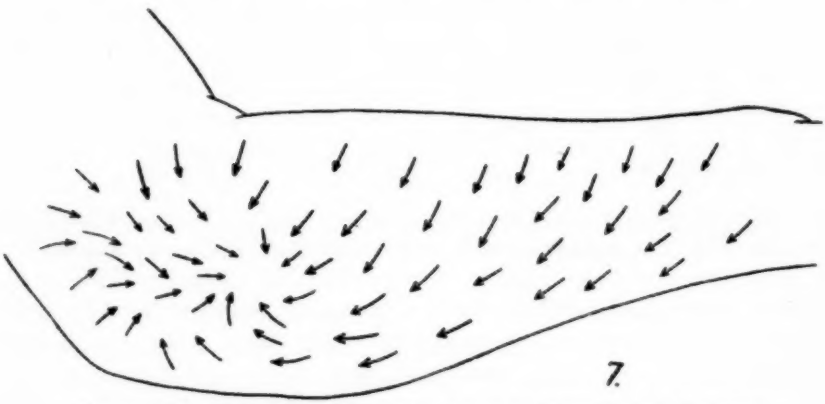

FIG. 7. ULNAR BORDER OF RIGHT FOREARM OF CHIMPANZEE FOETUS

other Lemurs the ulnar border is a line of convergence for the hairs which sweep obliquely from the dorsal and ventral surfaces of the forearm. But the radial whorl, as it appears first in the Lemurine order, belongs to the Lemurine type of the hair tracts of the forearm.

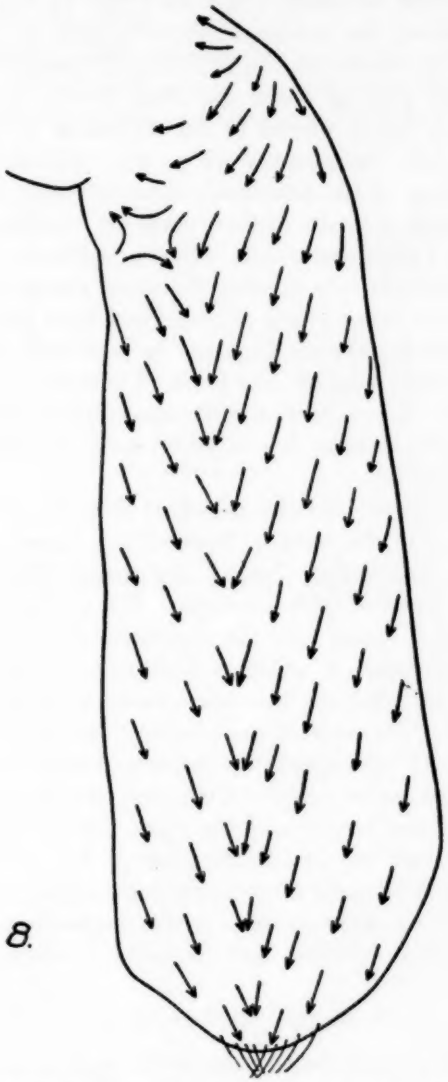

FIG. 8. ULNAR BORDER OF RIGHT FOREARM OF GORILLA FOETUS

In Tarsius, the hairs on the radial border are directed distally; the ulnar surface is hairless. In *Cebus* (Fig. 4), the type of the hair tracts of the forearm reaches a further stage of differentiation. Along a small part of the posterior border of the ulna, a hair stream proceeds straight towards the olecranon. *Macaca* (Fig. 5) has a well-marked long hair tract along this border which terminates in an anticlockwise whorl medial to the olecranon. In *Hylobates* I found this ulnar stream quite perfect and passing along the ulnar border to the olecranon. The anticlockwise whorl medial to the olecranon in the Macaque is also there but very rudimentary (Fig. 6). Consequently the first primitive beginning of the proximally-directed ulnar stream is found in the Platyrrhines, a more distinct stage of development occurs in Macaque in the Catarrhine group, while a perfectly developed stage is reached in *Hylobates*. As regards the whorl medial to the olecranon its first appearance takes places in the Catarrhine group and its development reaches a rudimentary stage in *Hylobates* (Fig. 6), but I found it in the same location also in the Chimpanzee (Fig. 7). The Gorilla, however, has a perfect tuft immediately on the olecranon (Fig. 8) to which all hairs are directed along the ulnar border, and the whorl is absent.

Schwalbe mentioned that the proximal direction of the hair tracts on the dorsal part of the hand in *Hylobates* is caused by the habit of this anthropoid progressing through the dense foliage of the trees by grasping the branches with the hands. But in the *Hylobates* foetus I have examined I found that the direction of the hairs is a distal one, because this radiating whorl is developed on the styloid process of the radius, from which the hair tracts sweep along the surface of the back of the hand. The cause of the proximal direction of the hair tract in the *Hylobates* of Schwalbe is the different location of this radiating whorl. In the species he examined this was developed on the base of the phalanges of the second and the third finger. Consequently the direction of the hair stream on the back of the hand must also be reversed, the whorl marking the starting point of the hair tract. In the Chimpanzee, in the Gorilla and also in the human foetus the radiating whorl has its typical location near the styloid process of the radius.

THE HAIR TRACTS OF THE SUBUMBILICAL AND PUBIC AREAS

The description of the hair tracts of the trunk may be restricted to those of the above-mentioned areas. The hairs on the lowest parts of the abdomen in *Chiromys* are transversely arranged and form a median

line of convergence at their caudal portion. The rare and very tender hairs on the abdomen of *Tarsius* converge from both sides to the middle line. In *Macaca* (Fig. 9), the hair tracts converge on the hypogastric area to a converging line. At the base of this line is a hairless triangle, and below this triangle sweep the hair tracts of the pubic area downwards to the genital organs.

In *Cercopithecus cephus,* between the umbilicus and the pubic region, there is a subumbilical line of convergence. The hairs of the inguinal folds converge to the genital organs. In the Chimpanzee and

FIG. 9. PUBIC AREA OF MACACA MULATTA FOETUS

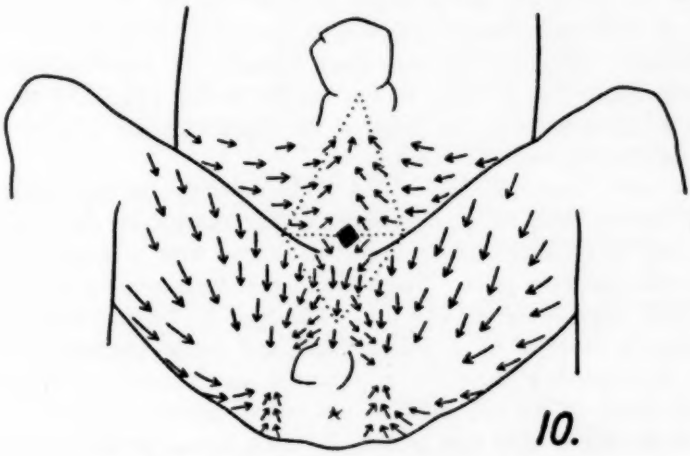

FIG. 10. PUBIC AREA OF CHIMPANZEE FOETUS

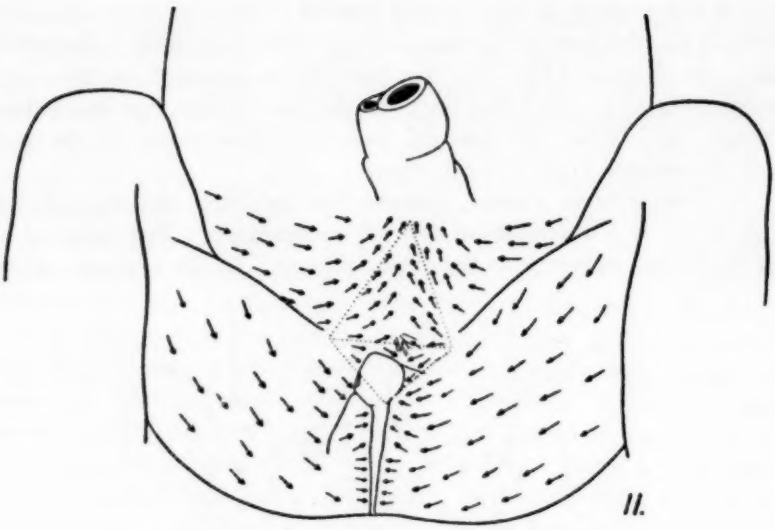

FIG. 11. PUBIC AREA OF GORILLA FOETUS

Gorilla, Bolk describes the direction of the hairs as downwards, but in both of my specimens I found the hair tracts converging upwards to the umbilicus (Fig. 10). The hair tracts form two acute-angled triangles on the hypogastric area; first, a subumbilical triangle, in which the hair tracts of both sides proceed obliquely upwards forming its apex at the umbilicus; and secondly, a pubic triangle, in which the hair tracts of both sides sweep obliquely downwards, forming its apex at the genitals. The bases of both these triangles lie together, including a quadrangle in the middle. In the Gorilla foetus (Fig. 11) the hairs of the adjacent parts of the bases of the triangles push together forming a tuft in place of this quadrangle.

The early type of the hair tracts of the subumbilical and pubic areas is the median line of convergence, foreshadowed in the Lemurine stock, and more distinctly developed to extend over a larger proximal area in the pithecoid stock. The hairs of that type proceed transversely from both sides to the median line. The type of the hair tracts of the Anthropoids consists of a subumbilical and pubic triangle. In that way I distinguish a lemuroid, a pithecoid and an anthropoid type of the hair tracts of the subumbilical and pubic regions.

It is worthy of note that in man the male sexual hormone conserves and renders more intense the hair streams of the subumbilical area,

since in the male adult there is developed the typical arrangement of the subumbilical triangle. In the female, by the influence of the hormone, the subumbilical triangle is absent and there remains only the pubic triangle of the mons Veneris.

THE HAIR TRACTS OF THE PINNA

The authors who have described the hair tracts of the pinna in various species of apes confine themselves to a survey of the general arrangement of the hair tracts on the pinna as a whole. But the discovery of localized zones of these tracts which coincide in position with the auricular hillocks present during development suggested to me a study of the hair tracts of the pinna in relation to these primordia. Furthermore, Bolk did not mention any hair tracts of the pinna of the foetuses of the Chimpanzee and Gorilla, and as Duckworth (1904) in the Gorilla foetus of 7 cm., Schultz (1927) in the Gorilla foetus of

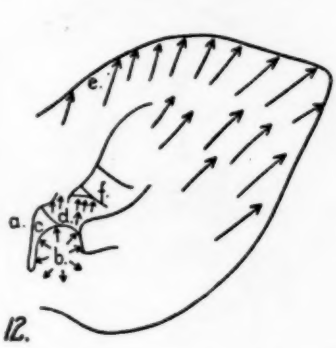

FIG. 12. PINNA OF CHIROMYS FOETUS

FIG. 13. PINNA OF LORIS FOETUS

The parts of the pinnae of the foetuses are labelled as: a = tragus, b = antitragus, c = incisura intertragica, d = crus helicis, e = helix, f = antihelix

8.5 cm., and Deniker (1885) in the Gorilla foetus of 13 cm. also missed them, the following description of the foetal hair tracts on the pinna of these anthropoids is the first to be published.

Chiromys (Fig. 12). Both the medial and the lateral surfaces of the helix, antihelix and concha are covered with chestnut-brown hairs directed slightly laterally and upwards. The crus helicis has short, denser hairs directed upwards, the ascending part of the helix and the

antihelix are hairless but the tips of the hairs of the pre-auricular area cover this hairless area. The tragus is hairless and the antitragus has a radiating whorl.

Loris (Fig. 13). The pinna of the smaller specimen is hairless on both sides excepting the tragus and the antitragus which have some small hairs directed sagittally. The crus helicis and the antihelix have the form of movable flaps which show some isolated hairs sweeping to the free border. The pinna of the larger specimen has five groups of hairs: the tragus has some isolated hairs, which proceed in three directions—anteriorly, upwards, and posteriorly; the antitragus has some tracts mostly directed downwards but also some anteriorly. Both the crus helicis and the antihelix are movable flaps and show isolated long hairs which sweep to their free borders. The ascending part of the helix has hair tracts directed upwards, the free posterior border of the pinna, backwards and the concha, downwards.

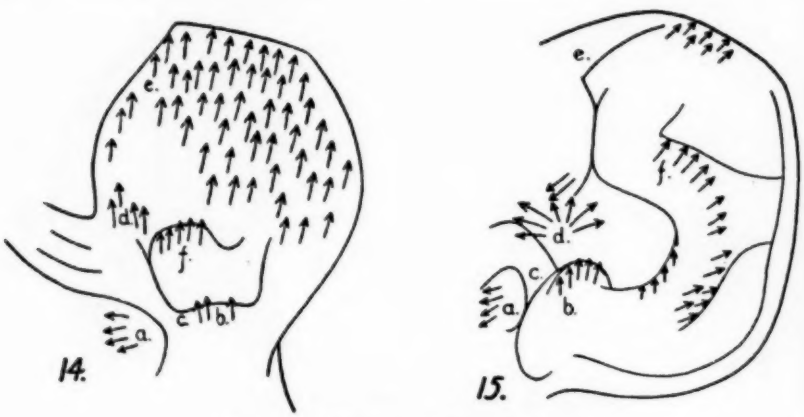

FIG. 14. PINNA OF TARSIUS FOETUS
FIG. 15. PINNA OF CEBUS FATUELLUS FOETUS

Tarsius (Fig. 14). The hair tracts on the medial and lateral surfaces of the helix and antihelix are directed upwards. The isolated group on the crus helicis and the isolated group on the projecting lobe of the antihelix also proceed upwards. The hairs on the tragus sweep anteriorly, those of the antitragus, cranially.

Cebus fatuellus (Fig. 15). The hair tracts on the tragus are directed forwards, on the antitragus, upwards. The crus helicis possesses a radiating whorl and above it some hairs directed forwards. On the

antihelix and on the upper border of the helix the hair tracts sweep obliquely upwards The medial side of the pinna is hairless.

Pithecia. Only the lowest part of the antihelix shows some short, isolated, colorless hairs; all other parts are hairless.

Cercopithecus grayi and cephus (Fig. 16). The pinnae of the Macaque and *Cercopithecus grayi* are hairless. The tragus of *cephus* is hairless, and the antitragus has densely arranged hairs directed downwards. The crus helicis shows a transverse crest, its upper row has hairs directed upwards and forwards. The antihelix has hair tracts directed upwards and slightly forwards. The upper border of the helix has hair tracts directed horizontally backwards, and the lower two-thirds of the helix, upwards and backwards.

Cercopithecus cynosurus (Fig. 17). The tragus is hairless as is the case also in *Cercopithecus cephus;* the crus helicis has hair tracts

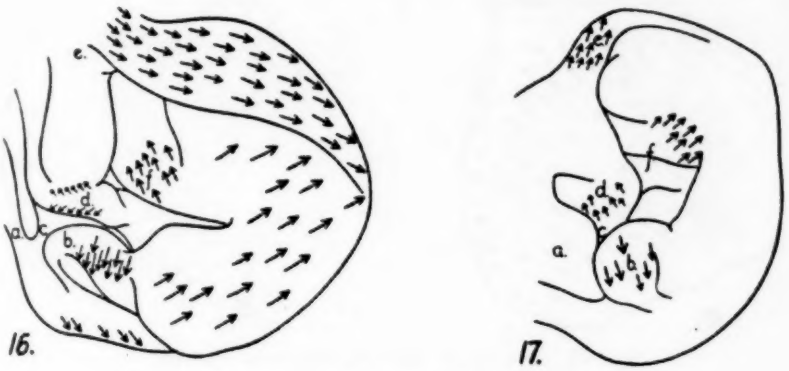

FIG. 16. PINNA OF CERCOPITHECUS CEPHUS FOETUS
FIG. 17. PINNA OF CERCOPITHECUS CYNOSURUS FOETUS

directed upwards. The anterior part of the upper border of the helix and the antihelix have hair tracts directed upwards and slightly backwards.

Macaca (Fig. 18). Both the tragus and antitragus have hairs directed backwards but the convexity of the hairs on the former is directed upwards, and that of the latter, downwards. The hair tracts on the crus helicis are directed upwards. The hair tracts on the upper part of the helix trend towards the upper angle, and on the flap-like part of the organ the tendency is also to point upwards. This character

resembles that described by W. C. Osman Hill on the grey langur *Semnopithecus Priam Thersites,* which belongs also to the Catarrhines.

Anthropoidea: Hylobates (Fig. 19). The pinna has only on the crus helicis some small hairs directed forwards and obliquely upwards, some others on the upper border of the helix directed upwards and backwards, and some hairs directed backwards on the upper third of the antihelix.

Chimpanzee (Fig. 20). The middle of the tragus has hairs directed downwards. Its posterior border has hairs directed backwards which cover the incisura intertragica. On the antitragus is a radiating whorl, its anterior part covering the incisura intertragica from behind. The crus helicis has hair directed upwards which turn anteriorly. The lower part of the antihelix has some small hairs directed backwards.

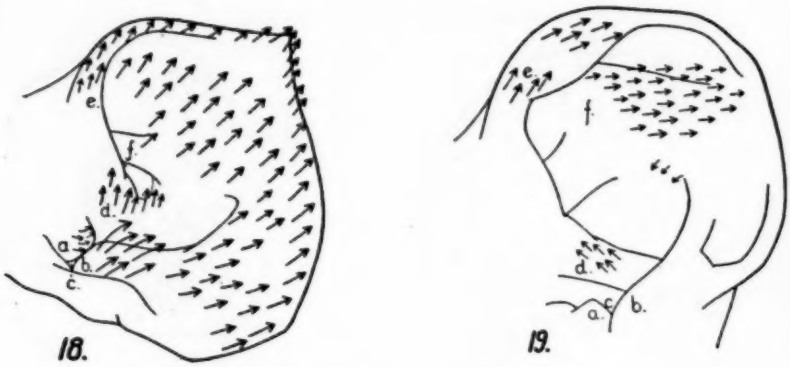

FIG. 18. PINNA OF MACACA MULATTA FOETUS
FIG. 19. PINNA OF GIBBON FOETUS

The hair tracts proceed upwards and slightly backwards to the tip of the auricle on the upper border of the helix. On the posterior border of the pinna the hairs are directed backwards. The incisura intertragica shows some small hairs directed upwards. Therefore, the external aperture of the auditory meatus is covered by hairs which sweep upwards from in front of the tragus, from the tragus, and from behind from the antitragus.

Gorilla (Fig. 21). The tragus is hairless. On the antitragus the hair tracts proceed forwards and upwards. The crus helicis has hair tracts arranged transversely which turn slightly downwards at their

tip. The hair tracts are directed backwards and slightly upwards to the tip of the auricle on the upper border of the helix, on the antihelix, and on the whole lateral surface of the helix. The external aperture of the auditory meatus is covered by hairs which proceed from three directions: from above by some small downward-directed hairs on the crus helicis, from below by some hairs directed upwards on the incisura intertragica, and from behind by the hairs on the antitragus.

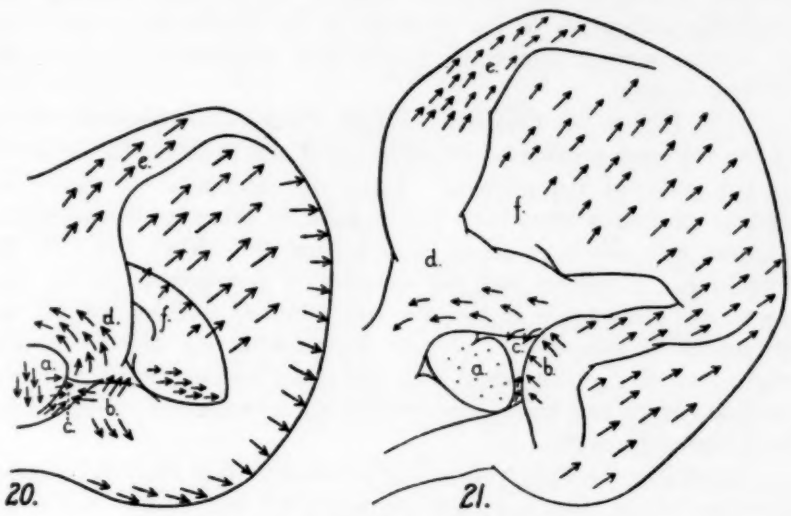

FIG. 20. PINNA OF CHIMPANZEE FOETUS
FIG. 21. PINNA OF GORILLA FOETUS

DISCUSSION

Most authors are of the opinion that the primitive arrangement of the hair tracts is as follows: The slope is from the tip of the snout to the caudal extremity of the body along the head, the neck and the trunk (W. Kidd, 1900, 01; G. Schwalbe, 1910, 11.). On the limbs, the direction is from the proximal to the distal end. *Ornithorhynchus* shows this primitive type of hair slope while Marsupials depart from it with only slight changes. We might therefore suppose that the hair tracts of the Lemurs when compared with those of the higher Primates would also exhibit this primitive type. Actually only *Chiromys* possesses the above-mentioned primitive arrangement; Figure 3 shows the simple and uniform type of its hair slope. Excepting

Chiromys, all other Lemurs possess a reversed area of the hair on the back part of the head. In *Loris lydekkerianus* this area of reversal is related to two radiating whorls on the back at the level of the upper ends of the scapulae. Fig. 2 shows some examples of the complicated arrangement of the hair tracts of this Lemur—the cross of the neck between the two whorls, the median converging centre of the vertex, and its supra-auricular stream. In his work on the hair tracts of the Lemurs, Schwalbe also included *Tarsius*, but he only mentions the noticeable differences in the direction of the hair tracts of the limbs of *Tarsius* without attempting to give any explanation of the causes of these features.

J. P. Hill in his Croonian Lecture on the developmental history of the Primates provided a classification of the Primates based largely on the study of the placenta. From the standpoint of this work, *Tarsius* exhibits a remarkable combination of primitive Monodelphian features with others in which it anticipates the higher Primates, the Pithecoids. I suggest that the complicated arrangement of the hair tracts in *Loris*, which is also the rule in other Lemurs, i.e. the development of two whorls, already foreshadows the higher Tarsioid stage, consisting of one whorl only, and that *Chiromys*, in the primitive condition of its hair tracts, has retained the arrangement typical of the basal Lemurine stock.

Concerning the Platyrrhines, it is noteworthy that *Pithecia* possesses the same typical whorls, a right one and a left one on the back at the level of the upper ends of the scapulae, as does *Loris*. These whorls are the starting points of the stream of hair which sweeps upwards across the occiput and vertex to the forehead without any interruption by the underlying fontanelle. In *Cebus* and in all the other Platyrrhines, Catarrhines, and Anthropoids which I have examined, including man, this upward direction of the hair stream is absent. It is noteworthy that A. H. Schultz describes in the Orang a radiating whorl at the cervical region from which the hairs of the back part of the head sweep upwards.

We can therefore distinguish four types of hair tracts of the scalp:

(1) *The primitive mammalian type*, from the front, backwards—the type realized in *Chiromys, Cebus, Macaca, Cercopithecus, Chimpanzee, Gorilla*, and *Hylobates*.

(2) *The Lemurine type*, consisting of two whorls on the back, from which the hairs of the back part of the head proceed upwards.

(3) *The Tarsioid type,* consisting of one whorl only on the back, realized in *Tarsius* and the Orang.

(4) *The Anthropoid type,* consisting of the parting in combination with the primitive mammalian type in the Chimpanzee and the Gorilla and with the Tarsioid type in the Orang.

The differentiation of these types in the different suborders of the Primates reveals neither their successive phylogenetic nor their systematic groups.

The areas of the skin belonging to the homologous structures of the face have their own hair tracts and may be divided into three groups: (1) the hair tracts of the fronto-nasal area, (2) those of the maxillary areas, and (3) those of the mandibular areas. The fronto-nasal area includes the parts of the face developed on the base of the embryonic fronto-nasal process, i.e. the hair tracts of the nose, forehead up to the vertex, upper lid, and median part of upper lip. The median line of convergence of the back of the nose appears in *Chiromys, Tarsius,* and *Cebus;* in *Cercopithecus* it is restricted to the forehead. In the Anthropoids, this area is hairless. The median part of the upper lip, as the lowest part of that median nasal process, has a special type of differentiation of the hair tracts, different from that of the adjacent lateral parts of the upper lip which belongs to the embryonic structure of the maxillary process. On this median part of the upper lip the hairs are directed downwards in *Pithecia* and *Cercopithecus;* in *Macaca* they sweep upwards; in the Chimpanzee and Gorilla there are some sagittally implanted isolated hairs. That area is hairless in the Orang foetus (A. H. Schultz).

The hair tracts of the maxillary area include those on the skin of the face which are developed on the base of the embryonic maxillary process, i.e. the hair tracts of the cheek, the lower lid of the eye and the lateral parts of the upper lip.

The hair tracts of the lateral parts of the upper lip and of the cheek are the same in all the species that I examined. The converging line of the cheek is the result of a crest formed by the backward and obliquely downward-directed hair tracts of the lateral parts of the upper lip and of the anterior part of the cheek and otherwise by the forward-directed hair tracts of the pre-auricular and mandibular area. As the former area develops on the base of the embryonic maxillary process, and the latter on the base of the first visceral arch, I suggest that the *line of convergence of the cheek is developed on the line of fusion of those*

homologous structures. In the Anthropoids, I found it in the Chimpanzee and Gorilla. It also exists in the Orang (Trinchese, 1870; Schwalbe, 1911; A. H. Schultz, 1933) and in *Hylobates* (Schwalbe, 1911).

The homologous structures of the pinna, like those of the face, have their own hair tracts and are related to the three mandibular and the three hyoid hillocks. This new result elucidates at once the significance of some embryonic structures of the pinna. In his work upon the development of the auricle, G. L. Streeter (1922) shows that the auricle consists of two parts derived anteriorly from the mandibular bar and posteriorly from the hyoid bar. A portion of the anterior part is the crus helicis or root of the helix (A. Keith, 1904), and a portion of the posterior, is the crus inferius antihelicis or plica principalis of Boas (1912). The work of Streeter (1920) shows that the crus helicis is not a part of the helix from which it differs embryologically. The crus helicis constitutes the lateral rim of the bowl-shaped pars articularis which offers a contact surface suitable for its attachment to the skull. The plica principalis is a fold which projects from the conchal floor as a free flap.

Comparing the arrangement of the hair tracts of the pinna in the different species of the suborders of the Primates, we find that the above-mentioned *embryological structures of Streeter have their own hair tracts.* The hair tracts are directed upwards and forwards on the crus helicis for the three anthropoids, *Hylobates,* Chimpanzee, and Gorilla, while those of the helix itself sweep downwards to the tip of the pinna. These differences of the hair tracts of the crus helicis and of the helix can be recognized also in the Cercopithecidae and in *Cebus.* For these two parts, the direction of the hair tracts in the Cercopithecidae resembles more closely that of the Anthropoids than that of *Cebus.* The projecting flap of the plica principalis is most marked in *Loris* and is characterized by a special hair tract.

In contrast to the different types of the hair tracts of the scalp which change during phylogenetic development, but independently of the successive phylogenetic series of the suborders of the Primates, the type of the hair tracts of the cheek, characterized by the median line of convergence of the cheek, is preserved in each species of the different suborders. On the other hand, the different types of the hair tracts of the forearm confirm the subdivision of the order which J. P.

PLATE I

FIG. 1. HEAD OF THE CHIMPANZEE FOETUS SHOWING THE PARTING, THE MEDIAL AND LATERAL PARTS OF THE EYEBROWS, THE EYELASHES, THE CONVERGING LINE OF THE CHEEK, THE HAIRS OF THE CHIN, THE HAIR TRACTS OF THE UPPER ARM AND FOREARM

FIG. 2. HEAD OF THE CHIMPANZEE FOETUS SHOWING THE HAIRS OF THE SIDE AND OF THE OCCIPUT OF THE HEAD, ON THE BACK AND ON THE PINNA

FIG. 3. HEAD OF THE CHIMPANZEE FOETUS SHOWING THE HAIRS OF THE SCALP AND ON THE DORSAL ASPECT OF THE HAND

FIG. 4. FOETUS OF THE CHIMPANZEE TO SHOW ITS POSITION AND THE RATE OF DEVELOPMENT OF THE HAIRS OF THE SCALP AND OF THE BODY

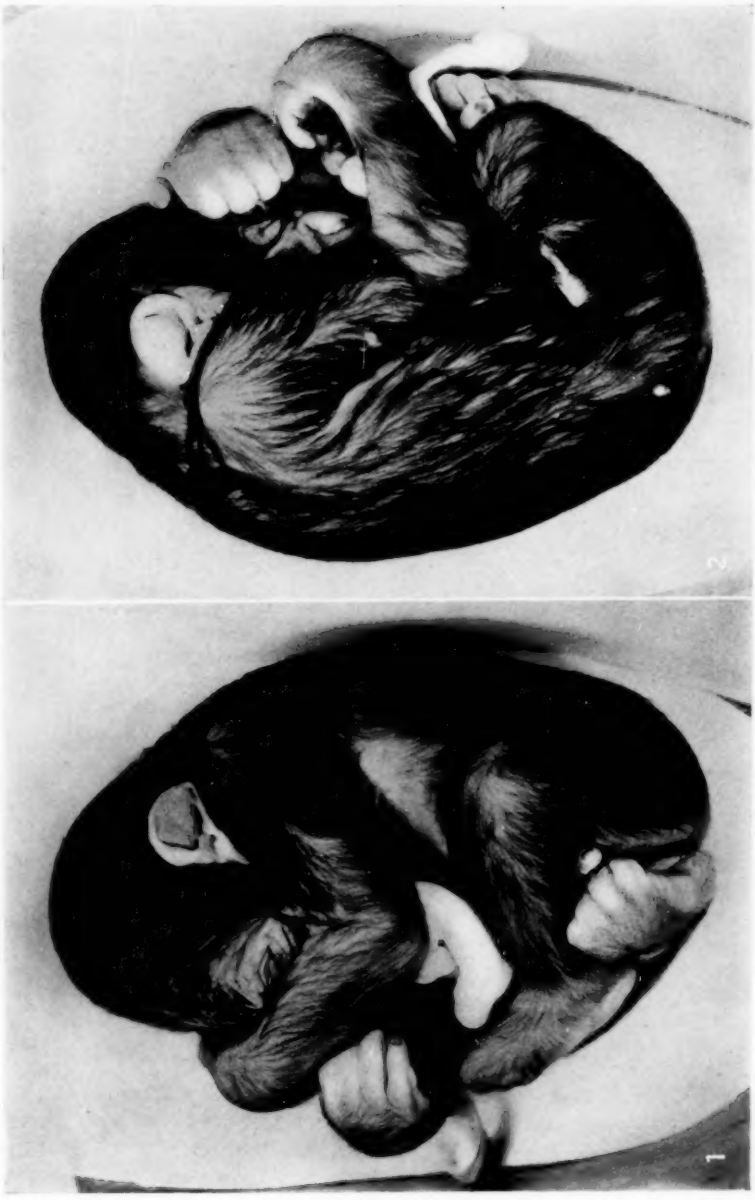

PLATE II

FIG. 1. LEFT SIDE OF THE GORILLA FOETUS

FIG. 2. RIGHT SIDE OF THE GORILLA FOETUS

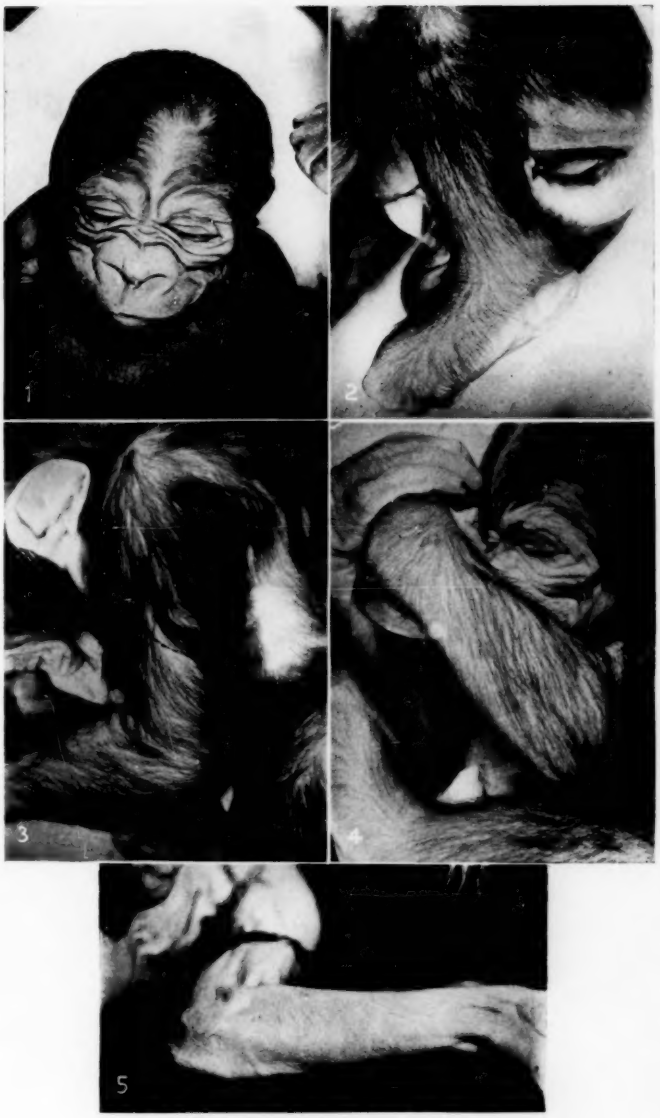

Plate III

Fig. 1. Head and Chest of Gorilla Foetus

Fig. 2. Lateral Aspect of Left Leg of Gorilla Foetus

Fig. 3 and 4. Upper Extremity of Gorilla Foetus

Fig. 5. Ulnar Border of Forearm of Macaca mulatta to Show the Whorl near the Olecranon

Hill has postulated in his work on the developmental history of the placenta.

The hair tracts of the subumbilical and pubic areas can be distinguished into three types: (1) a Lemuroid, with a suprapubic line; (2) a Pithecoid, with a subumbilical line; (3) an Anthropoid, with a subumbilical triangle as well as a pubic triangle. As I have shown elsewhere (1931), constitution is a mosaic. The haircoat consists of special hair tracts on certain areas which develop on the base of the homologous structures. A primitive type of the hair tracts of those areas may persist during phylogenetic development, or it may change and be replaced by another type. Most of the types of any area appear in different species simultaneously. Others may appear on certain areas synchronously with the successive phylogenetic series of the suborders of the Primates. In that way the haircoat is a combination of different types of hair tracts, which are biologically common to all Primates. The appearance of any type of any area depends on its time curve of differentiation in the species. A fast curve in a primitive suborder "foreshadows" the type of a higher suborder, a slow curve in a more advanced suborder reveals a "primitive" type.

I hope that this synthetic constitutional point of view may be applicable to human biology.

I take this opportunity of expressing my grateful thanks to Professor J. P. Hill for placing the foetuses herein described at my disposal. Also I wish to tender my very sincere thanks to Professor W. E. Le Gros Clark for the *Tarsius* foetus and to Dr. A. J. E. Cave for a new born Chimpanzee, both of which specimens were very kindly placed at my disposal.

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OBSERVATIONS ON THE SOMATIC CONSTITUTION OF MOTHERS WITH AND WITHOUT INFANT MORTALITY AMONG THEIR PROGENY[1]

BY HENRI C. SEIBERT

I. THE PROBLEM AND MATERIAL

ONE aspect of the study of human constitution is to analyze the relationships between external morphological appearances and the physiological, pathological, and psychological characteristics of the individual. In this study an attempt has been made to seek some correlation between the somatology of mothers and the infant mortality (deaths under one year of age) occurring among their offspring. It has been pointed out[2] that many infants die from unknown causes, probably attributable in part at least, to some innate biological weakness of the reproductive mechanism of the mother. From this point of view the constitution of mothers who had had some infant deaths was investigated in order to ascertain whether or not these individuals differed in any manner from mothers whose reproductive histories showed no infant deaths.

For this purpose, the Constitutional Records of the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University were used. These records have been extensively described by Pearl, Sutton, Howard, and Rioch[3] and need not be fully discussed here. Suffice it to say that patients studied in the constitutional work were examined on a threefold basis: clinical medicine and path-

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[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University.

[2] Cf. Seibert, H. C. The progress of ideas regarding the causation and control of infant mortality. *Bull. of the History of Med.*, Vol. 8, pp. 546-598, 1940, where the literature is reviewed.

[3] Pearl, R., A. C. Sutton, W. T. Howard, Jr., and M. Rioch. Studies on constitution. I. Methods. HUMAN BIOLOGY, Vol. 1, pp. 10-56, 1929.

ology, anthropometry, and genetics. These patients were drawn primarily from the wards of the Johns Hopkins Hospital. Only white patients were studied.

On the genetic forms were entered the children of the patient, including stillbirths, miscarriages, and abortions, and the age of death of the infants. The race and racial stock of the patient was recorded. The clinical form gives a complete record of the medical history of the patient with past and present pathological symptoms, and the results of a clinical examination. The anthropometric forms include measurements of weight and height and other linear dimensions, as well as various girth measurements of the head, chest, umbilicus, etc. On the basis of direct examination of the nude patients and photographs, each patient was classified for both legs and trunk on a bodily habitus scale ranging from an extreme asthenic body build to an extreme pyknic.

For this study only women who had had at least one live birth were selected. Of these there were 262. Women who had had no live births were excluded because they had not had the chance of having any infant dying before reaching the age of one. All the offspring were legitimate. Cases involving illegitimacy were excluded to avoid too many complicating factors.

The 262 women included in this study were first divided into those who had had one or more children dying under one year of age, and those who had not. To save space and to avoid repetition of expressions "with" and "without infant mortality" the two groups will hereinafter be designated as *A* (the group of women without infant deaths, IM = 0) and *B* (the group with infant deaths, IM > 0).

2. AGE DISTRIBUTION OF MOTHERS

The *B* group is found to average 5.2 years older than the *A* group. The biometric constants are as follows:

	A (IM = 0)	*B* (IM > 0)
Mean age (*yrs.*)	45.31 ± 0.64	50.51 ± 0.84
Median age (*yrs.*)	44.90 ± 0.80	51.03 ± 1.05
Standard deviation (*yrs.*)	12.39 ± 0.45	11.96 ± 0.59
N	169	93

While the difference of 5.2 years is statistically significant, the amount is too small to affect somatological measurements to an appreciable degree.

3. RACE

In Table 1 the women are distributed in broad groups according to their racial origins. As in all such data "racial origin" is to be construed rather loosely. What it practically amounts to is country of birth, save in the case of the Hebrew category. Here the connotation is that the persons so designated were in fact Jews.

TABLE 1

Distribution of mothers according to racial origin

RACIAL ORIGIN	*A* (IM = 0)		*B* (IM > 0)	
	Number	Percent	Number	Percent
Scandinavian	1	0.60	0	0.00
German, Dutch, Flemish	8	4.82	2	2.15
Russian, Slovak, Polish, Magyar, Bohemian, Bulgarian, Rumanian	6	3.61	7	7.52
Hebrew	19	11.44	12	12.90
English, Irish, Scotch, Welsh	6	3.61	2	2.15
Italian, French, Spanish, Greek	2	1.20	2	2.15
North American	124	74.70	68	73.10
Total	166	99.98	93	99.97

The table shows that for each group (*A* and *B*) nearly three quarters of the women were born in this country. Over one-third of these were second generation Americans; 35.75 percent in the *A* (IM = 0) group and 39.77 percent in the *B* (IM > 0) group. The only other racial stock well represented was the Hebrew with an incidence of approximately 12 percent in each group.

That the two groups do not differ significantly was shown by a chi-square test which gave the value of 4.34 and a probability of 0.63. In other words in 63 out of 100 trials we should expect a difference as great as or greater than the one shown in Table 1. It may safely be said that the two groups of mothers are substantially alike with respect to race.

4. DIRECT ANTHROPOMETRIC MEASUREMENTS

Table 2 shows the means, medians, and standard deviations, and the probable errors of these constants, for the somatic measurements of the

TABLE 2

Biometric constants of direct somatic measurements of women with infant mortality and those without

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	DIFFERENCES BETWEEN THE MEANS OF THE *A* AND *B* GROUPS
Body weight (*kg.*)					
A (IM = 0)....	167	66.18±0.87	64.58±1.08	16.60±0.61	—0.98±1.51
B (IM > 0)....	88	67.16±1.23	66.15±1.54	17.07±0.87	
Span (*cm.*)					
A.....	166	158.87±0.41	159.37±0.52	7.88±0.29	+1.76±0.62
B.....	90	157.11±0.47	156.78±0.59	6.68±0.33	
Stature (*cm.*)					
A.....	169	157.49±0.36	157.73±0.45	6.87±0.25	+2.53±0.57
B.....	93	154.96±0.44	155.55±0.55	6.28±0.31	
Ext. aud. canal height (*cm.*)					
A.....	169	144.10±0.34	144.44±0.43	6.61±0.24	+2.42±0.56
B.....	93	141.68±0.44	142.41±0.55	6.27±0.31	
Suprasternal notch height (*cm.*)					
A.....	169	129.07±0.32	129.12±0.41	6.28±0.23	+2.39±0.51
B.....	93	126.68±0.40	127.28±0.50	5.74±0.28	
Lower costal margin height (*cm.*)					
A.....	167	102.45±0.27	102.71±0.34	5.25±0.19	+2.03±0.45
B.....	90	100.42±0.36	100.91±0.45	5.03±0.25	
Sitting height (*cm.*)					
A.....	168	83.40±0.20	83.61±0.25	3.81±0.14	+1.09±0.32
B.....	93	82.31±0.25	82.43±0.32	3.63±0.18	
Trunk length (*cm.*)					
A.....	167	54.22±0.16	54.52±0.20	3.12±0.11	+0.36±0.26
B.....	93	53.86±0.21	53.95±0.26	2.99±0.15	
Head breadth (*cm.*)					
A.....	168	14.75±0.05	14.76±0.06	0.99±0.04	—0.07±0.09
B.....	93	14.82±0.07	14.76±0.09	1.00±0.05	
Head length (*cm.*)					
A.....	168	18.04±0.05	18.21±0.07	1.05±0.04	—0.05±0.09
B.....	93	18.09±0.06	18.24±0.08	0.87±0.04	

TABLE 2 (*Cont.*)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	DIFFERENCES BETWEEN THE MEANS OF THE *A* AND *B* GROUPS
Cephalic index					
A	168	80.40±0.22	80.38±0.28	4.22±0.15	—0.68±0.36
B	93	81.08±0.28	81.42±0.35	3.99±0.20	
Biacromial breadth (*cm.*)					
A	168	34.39±0.10	34.48±0.13	2.02±0.07	+0.05±0.18
B	93	34.34±0.15	34.04±0.19	2.20±0.11	
Bi-iliac breadth (*cm.*)					
A	167	28.86±0.14	28.83±0.18	2.75±0.10	—0.24±0.23
B	93	29.10±0.18	29.17±0.22	2.56±0.13	
Greatest hip breadth (*cm.*)					
A	167	34.75±0.20	34.79±0.25	3.90±0.14	—0.37±0.34
B	93	35.12±0.27	35.03±0.34	3.88±0.19	
Sagittal chest depth (*cm.*)					
A	169	19.89±0.15	19.71±0.19	2.90±0.11	—0.74±0.27
B	92	20.63±0.22	20.80±0.27	3.09±0.15	
Head circumference (*cm.*)					
A	165	54.90±0.08	54.91±0.10	1.52±0.06	+0.18±0.14
B	91	54.72±0.11	54.67±0.14	1.59±0.08	
Neck girth (*cm.*)					
A	168	33.98±0.16	33.56±0.20	3.05±0.11	—0.68±0.27
B	93	34.66±0.22	34.25±0.28	3.21±0.16	
Chest girth—rest (*cm.*)					
A	166	89.14±0.51	88.33±0.64	9.69±0.36	—0.75±0.91
B	92	89.89±0.75	90.00±0.94	10.72±0.53	
Chest girth—inspiration (*cm.*)					
A	166	91.07±0.51	90.23±0.64	9.79±0.36	—0.75±0.90
B	92	91.82±0.73	91.82±0.92	10.44±0.52	
Chest girth—expiration (*cm.*)					
A	166	87.63±0.50	87.04±0.63	9.63±0.36	—1.25±0.91
B	92	88.88±0.76	89.37±0.96	10.89±0.54	
Umbilical girth (*cm.*)					
A	168	93.93±0.94	92.08±1.18	18.13±0.67	—3.62±1.59
B	93	97.55±1.29	99.64±1.62	18.44±0.91	

two groups. The differences are stated as *plus* when the *A* (IM = 0) mean is greater than the *B* (IM > 0) mean, and *minus* when the opposite is the case.

The following differences appear:

1. The *B* (IM > 0) group has a mean body weight of .98 kg. more than the *A* (IM = 0) group. The difference is obviously not significant.

2. The *A* (IM = 0) group, for all of the five height measurements, has higher average values than the *B* (IM > 0) group. The differences of the means with the probable errors of the differences are as follows: Stature, $+2.53 \pm .57$ cm.; Height at exterior auditory canal, $+2.42 \pm .56$ cm.; Height at suprasternal notch, $+2.39 \pm .51$ cm.; Height at lower costal margin, $+2.03 \pm .45$ cm.; Sitting height, $+1.09 \pm .32$. It will be seen that all the differences in means are more than three times their probable errors, and are therefore to be regarded as probably significant.

3. The mean span is greater by $+1.76 \pm .62$ cm. in the *A* (IM = 0) group, a difference that falls short of statistical significance. The mean trunk length for the two groups does not differ by more than .4 centimeters.

4. Mean head length and breadth do not differ significantly in the two groups. The mean cephalic index is 0.68 greater for the *B* (IM > 0) group, but this difference is less than twice its probable error.

5. The mean biacromial, bi-iliac, hip, and sagittal chest diameters show no significant differences.

6. For the girth measurements, the mean head circumference fails to show any significant difference. The mean neck girth is a little greater in the *B* group, but the difference in not statistically significant.

7. The mean umbilical girth is 3.62 cm. greater in the *B* (IM > 0) group but the probable error of the difference is so great (1.59 cm.) that the difference is not statistically significant. The mean values for the chest girths at rest, inspiration, and expiration are all greater for the *B* group but in no case is the difference of significant proportions.

These anthropometric comparisons show that mothers who experienced infant mortality among their offspring were definitely shorter in the vertical linear measurements than those who had not. At the same time this *B* (IM > 0) group had somewhat greater measurements in

the horizontal axes, but this greater size in girth was not sufficiently great to be significant so far as may be judged from samples of this size.

This point is further borne out by the body weight ratio. For the *A* (IM = 0) group this index is 41.90 ± 0.54, and for the *B* group, 43.06 ± 0.76. While these indices are not significantly different from one another, they nevertheless indicate that the *A* group is taller per unit of weight than the *B* group.

The difference to be found in the mean chest expansion index between the two groups is of interest. The mean for this index, calculated as $\frac{\text{chest girth at inspiration} - \text{chest girth at expiration}}{\text{chest girth at expiration}}$ is 4.54 ± 0.13 for the *A* group and 3.78 ± 0.14 for the *B* group. The difference, —0.76 ± 0.19, is four times its probable error. The greater lung capacity of the *A* group agrees with the findings of Pearl and Ciocco [4] and Ciocco [5] who found a higher index for their non-cardiac patients (asthenics) than for the cardiacs (pyknics).

TABLE 3

Incidence of disease conditions

DISEASE	*A* (IM = 0)		*B* (IM > 0)	
	Number	Percent	Number	Percent
Hypertension	68	40.2	38	40.8
Syphilis	21	12.4	17	18.3
Cancer	23	13.6	11	11.8
Cardiac disease	13	7.7	9	9.7
Obesity	14	8.3	12	12.9
Diabetes	6	3.5	12	12.9
Respiratory disease	5	2.9	7	7.5
Miscellaneous	32	18.9	9	9.7
No disease	13	7.7	9	9.7

[4] Pearl, R. and A. Ciocco. Studies on constitution. II. Somatological differences associated with diseases of the heart in white males. HUMAN BIOLOGY, Vol. 6, pp. 650-713, 1934.

[5] Ciocco, A. Studies on constitution. III. Somatological differences associated with diseases of the heart in white females. HUMAN BIOLOGY, Vol. 8, pp. 38-91, 1936.

5. PATHOLOGY

An analysis of the clinical findings on these women reveals that hypertension was by far the commonest complaint. Table 3 shows that high blood pressure was found in nearly identical proportions in both groups.

Respiratory disturbances were more prevalent in the *B* group, although relatively infrequent in both of the groups. Cancer was more common in the *A* group, but not significantly so. The greater prevalence of obesity and diabetes mellitus in the *B* group is interesting as this finding goes hand in hand with the results of the measurements, i.e. that the *B* group is heavier, and of broader proportions than the *A* group. Diabetes, which is essentially an emaciating disturbance, is nevertheless frequently found among the obese. The average values of four measurements for the diabetics are given below:

	A (IM = 0)	*B* (IM > 0)
N	6	12
Body weight	64.2 kg.	76.9 kg.
Stature	154.6 cm.	153.7 cm.
Chest girth	88.6 cm.	97.7 cm.
Umbilical girth	92.3 cm.	111.4 cm.

It will be seen that the *B* group of diabetic women were definitely heavier, shorter, and had greater girths than either the *A* group diabetics, or the total *A* and *B* groups of Table 2.

It is a well-known and established fact that syphilis is a direct cause of many infant deaths. In this group of women there were 38 cases of syphilis, 17 occurring in the *B* (IM > 0) group and 21 in the *A* (IM = 0) group, giving an incidence of 18.3 and 12.4 percent respectively.

TABLE 4

Measurements of women without syphilis

	GROUP *A*			GROUP *B*		
	N	Mean	S.D.	*N*	Mean	S.D.
Body weight (*kg.*)	146	66.98±0.95	17.17±0.67	73	69.07±1.36	17.22±0.96
Stature (*cm.*)	148	157.30±0.39	7.14±0.28	76	154.80±0.50	6.55±0.36
Chest girth (*cm.*)	145	89.90±0.56	9.94±0.39	75	91.38±0.78	9.99±0.55
Umbilical girth (*cm.*)	147	95.15±1.02	18.42±0.72	76	100.46±1.39	17.98±0.98

Elimination of the women with definite luetic symptoms and those who gave a positive Wasserman reaction does not affect the relationship between the two groups, as is shown in Table 4.

With the elimination of women with syphilis, the *B* group is seen to be on the average heavier, shorter, and larger in girth for both chest and umbilicus. The difference in mean height is of the same proportion as appeared in Table 2; the differences in mean weight and girth measurements are, however, relatively greater than previously noted. While the weight and chest measurements are not significantly different, the mean umbilical girth is greater in the *B* group by 5.31 ± 1.72 cm., a difference that is more than three times its probable error.

Many of the women suffered from some sort of gynecological disturbance which in many cases necessitated major surgical operations. Since these disturbances ranged all the way from carcinoma of the cervix to pruritus vulvae, it was thought best to eliminate all women who had had some abnormality of the reproductive system, whether of major or of minor importance.

Table 5 gives the somatic measurements of women completely free from any gynecological disturbance.

TABLE 5

Anthropometric measurements of women with no gynecological history

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	DIFFERENCES BETWEEN THE MEANS OF THE *A* AND *B* GROUPS
Age (*years*)					
A (IM = 0)....	114	46.67±0.80	46.33±1.00	12.65± .56	—6.72±1.30
B (IM > 0)....	56	53.39±1.03	53.50±1.29	11.42± .73	
Body weight (*kg.*)					
A.....	112	67.23±1.05	65.00±1.31	16.42±0.74	—1.02±1.88
B.....	53	68.25±1.57	68.21±1.97	16.94±1.11	
Stature (*cm.*)					
A.....	114	157.19±0.47	157.50±0.59	7.48±0.33	+1.92±0.74
B.....	56	155.27±0.57	156.07±0.71	6.35±0.40	
Suprasternal notch height (*cm.*)					
A.....	114	128.86±0.44	129.00±0.55	6.91±0.31	+1.81±0.67
B.....	56	127.05±0.52	127.88±0.65	5.73±0.36	

TABLE 5 (*Cont.*)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	DIFFERENCES BETWEEN THE MEANS OF THE *A* AND *B* GROUPS
Lower costal margin height (*cm.*)					
A	112	102.50±0.36	102.80±0.45	5.61±0.25	+1.76±0.58
B	55	100.74±0.45	102.10±0.56	4.91±0.32	
Sitting height (*cm.*)					
A	114	83.31±0.25	83.50±0.32	4.05±0.18	+0.88±0.41
B	56	82.43±0.33	82.46±0.42	3.72±0.24	
Trunk height (*cm.*)					
A	113	54.26±0.20	54.53±0.25	3.11±0.14	+0.37±0.31
B	56	53.89±0.25	53.86±0.31	2.73±0.17	
Neck girth (*cm.*)					
A	113	34.07±0.18	33.47±0.22	2.82±0.13	−0.54±0.31
B	56	34.61±0.25	34.44±0.32	2.84±0.18	
Bi-iliac breadth (*cm.*)					
A	112	29.12±0.17	29.22±0.21	2.67±0.12	−0.41±0.29
B	56	29.53±0.24	29.45±0.30	2.64±0.17	
Greatest hip breadth (*cm.*)					
A	112	35.03±0.24	34.62±0.30	3.75±0.17	−0.74±0.44
B	56	35.77±0.38	35.77±0.48	4.22±0.27	
Chest girth—rest (*cm.*)					
A	113	89.55±0.60	88.75±0.75	9.47±0.42	−0.84±1.03
B	55	90.39±0.84	90.62±1.05	9.26±0.59	
Chest girth—inspiration (*cm.*)					
A	112	91.32±0.60	90.50±0.76	9.49±0.43	−0.79±1.00
B	55	92.11±0.80	91.96±1.00	8.80±0.57	
Chest girth—expiration (*cm.*)					
A	112	88.12±0.60	87.50±0.75	9.46±0.43	−1.22±1.03
B	55	89.34±0.84	90.14±1.06	9.28±0.60	
Umbilical girth (*cm.*)					
A	113	94.58±1.10	92.50±1.37	17.29±0.77	−5.15±1.91
B	56	99.73±1.57	101.36±1.97	17.47±1.11	

Fully one-third of the women had had some gynecological history. The incidence was 32.54 percent (55) for the *A* (IM = 0) group and 39.78 percent (37) for the *B* (IM > 0) group. In spite of the high incidence of these disorders the elimination of these women from the sample had no effect on the relationship between body build and infant mortality. The figures of Table 5 show the identical trends already noticed in Table 2. The differences between the means are in general smaller, and the probable errors are greater because of the smaller samples, with the result that the differences are mostly not statistically significant. Nevertheless it may be safely said that the gynecological pathology is not a factor causing the observed differences.

6. MENSTRUAL RECORD

Always of interest in any study of constitution in women is the factor of menstruation. Various bodily types have been associated with amenorrhea, dysmenorrhea, and other pathological disturbances of this physiological process.[6] Likewise age at menarche has also been shown to be in part dependent on the physiologic state of the female. In this group the age at onset of menstruation was as follows:

Group	*N*	*Mean age*	*Standard Deviation*
A	162	14.17 ± .09	1.77 ± .06
B	89	14.32 ± .12	1.67 ± .08

From these figures it is evident that there is no significant difference between the two groups in mean age at menarche, or variation in that age.

For the interval between menstrual flow the two groups have the following distributions:

Days	Group *A*		Group *B*	
	Number	*Percent*	*Number*	*Percent*
27 or fewer	16	10.16	4	4.49
28	131	82.91	79	88.76
29 or more	6	3.80	2	2.25
Irregular	5	3.16	4	4.49
Total	158	100.03	89	99.99

[6] Bayer, Leona M. Build in relation to menstrual disorders and obesity. *Endocrinology*, Vol. 24, pp. 260-269, 1939.

The application of a chi-square test shows that the two groups do not differ significantly in the length of the menstrual cycle. The value of χ^2 was 3.03 and $P = .39$.

Characteristics of flow	Group *A*		Group *B*	
	Number	*Percent*	*Number*	*Percent*
Painless—Average	63	39.87	41	46.06
Profuse	27	17.09	12	13.48
Scanty	5	3.16	4	4.49
Painful—Average	29	18.35	17	19.10
Profuse	28	17.72	13	14.60
Scanty	6	3.80	2	2.25
Total	158	99.99	89	99.98

While it appears that the *B* group had the larger proportion of women with an "average" flow, and the *A* group more women with a "profuse" flow, nevertheless the application of the chi-square gave the value of 2.03 and a *P* of .85. These values show that there is no significant difference between the groups in respect of this characteristic.

7. MORPHOLOGICAL TYPES

An indirect approach to a clearer conception of the somatological habitus of these women was made by classifying them into asthenic,

TABLE 6

Distribution of average body habitus types

TYPE	NUMBER	PERCENT
Asthenic (0-3)		
Group *A*	26	15.75
Group *B*	8	8.88
Intermediate (4-8)		
Group *A*	106	64.24
Group *B*	52	57.77
Pyknic (9-12)		
Group *A*	33	20.00
Group *B*	30	33.33
$\chi^2 = 6.64$	P = .037	

intermediate, and pyknic types. Patients were typed on a scale ranging from 0 (an extreme asthenic) to 12 (an extreme pyknic habitus). For the details of the typing technique used see Pearl *et al.*[3] The women were distributed as shown in Tables 6 and 7. In Table 6 the body type was taken as the average of both trunk and leg scale number. For example, if the trunk was 1 and the legs 5 (average of 3) that individual was considered an asthenic.

TABLE 7

Distribution of bodily habitus types with trunk and legs considered separately

TYPE	TRUNK		LEGS	
	Number	*Percent*	*Number*	*Percent*
Asthenic (0-3)				
Group *A*	31	18.79	28	16.97
Group *B*	10	11.23	10	11.23
Intermediate (4-8)				
Group *A*	101	61.21	108	65.45
Group *B*	48	53.92	48	53.92
Pyknic (9-12)				
Group *A*	33	19.99	29	17.58
Group *B*	31	34.83	31	34.83
	$\chi^2 = 7.61$	$P = .023$	$\chi^2 = 9.81$	$P = .0075$

These figures clearly show that the *A* group included an excess representation of asthenics and intermediates, while the *B* group had an excess of pyknics. The difference found in the average body type of Table 6 and in the trunk type of Table 7 is very probably significant. The difference in the legs type of Table 7 is most certainly significant.

The average of the scale numbers for each group shows that both trunk and legs were closer to the pyknic end of the scale in the *B* group of women.

Group	*Average trunk number*	*Standard deviation*	*Average leg number*	*Standard deviation*
A	$6.40 \pm .14$	$2.67 \pm .10$	$6.13 \pm .15$	$2.86 \pm .11$
B	$7.09 \pm .22$	$3.08 \pm .16$	$7.02 \pm .21$	$2.90 \pm .15$

The difference of the means of the trunk scale numbers is .69 ± .26, and for the leg scale numbers the difference is .89 ± .26. The latter difference is more than three times the probable error and is therefore probably statistically significant. We may therefore conclude that Group *A* differs from Group *B* in body habitus, tending more to an asthenic build both in trunk and legs, but more so with respect to the legs than to the trunk.

An index to the degree of dysplasia was formed by finding the difference in scale numbers of trunk and legs. The greater the amount of dysplasia, the larger the number. These numbers were derived irrespective of whether the trunk scale numbers was greater or smaller than that of the limbs.

		Degree of dysplasia	
Group	*N*	*Trunk*	*Legs*
A.....	166	1.28 ± .07	1.44 ± .05
B.....	88	1.39 ± .10	1.37 ± .07

It is apparent that the groups *A* and *B* do not differ significantly in the degree of dysplasia.

9. DISCUSSION

This work was prompted by a desire to discover the explanation of why some apparently normal women had children that died in infancy, and others, equally healthy, did not. As the study of infant mortality is pursued more and more, the conclusion that some inherent weakness in the biological make-up of the mother is a significant factor becomes stronger. So many infants die for no apparent pathological reason that it seemed reasonable to investigate this problem from a constitutional viewpoint.

Many studies in constitution have clearly demonstrated that some external morphological builds are more frequently associated with a tendency toward, or a susceptibility to, certain pathological or atypical disturbances, than are other body types (cf. Pearl[7]). Just why this relationship exists has not always been fully explained for the reason that sufficient knowledge is not yet at hand to reveal the cause and effect.

This study has demonstrated some interesting biological relationships that may eventually prove to be of some significance. The fact

[7] Pearl, R. Constitution and Health. *London* (Kegan Paul, Trench, Trubner and Co.), 1933.

that women who had had children dying before reaching the age of one were on the average shorter than women with no infant deaths is not to be taken to suggest that all short women will experience infant mortality among their progeny. Nor is it to be taken as suggestion that any somatic measurement of the mother has an effect *per se* on the infant's chances of survival or death. This paper deals solely with statistical associations, which show that in this sample, women experiencing infant deaths among their progeny were somatologically different from those who had had no such infant mortality.

10. SUMMARY AND CONCLUSIONS

Of 262 white mothers drawn from the wards of the Johns Hopkins Hospital, 169 had not experienced infant mortality among their offspring and 93 had. The somatic measurements of the former group, designated as *A* (IM = 0), were compared with those of the latter group *B* (IM > 0). The *B* group was found to be definitely shorter in mean stature, mean height at exterior auditory canal, mean height at suprasternal notch, mean height at lower costal margin, and mean sitting height, but not in mean trunk height. No significant differences were found for mean body weight, span, head length and breath, nor for the mean biacromial, bi-iliac, hip, and sagittal chest diameters. The mean girth measurements (especially at the umbilicus) were greater in the *B* group than in the *A*, but not significantly so.

Elimination of mothers with symptoms of syphilis, or those with a gynecological history, did not affect the comparative differences between the two groups.

Groups *A* and *B* did not differ with respect to age at menarche, interval between menstrual periods, or in the characteristics of the menstrual flow.

Group *A* tended toward the asthenic type of body build and group *B* toward the pyknic in both trunk and legs, but especially with respect to the latter.

There was no difference in the degree of dysplasia exhibited by the two groups.

To conclude, infant mortality appears to be associated with certain characteristics of the mother's constitutional somatology.

STUDIES ON TWINS[1]
II. ON THE EARLY MORTALITY OF LIKE-SEXED AND UNLIKE-SEXED TWINS

BY J. YERUSHALMY AND S. E. SHEERAR

THE hazards of multiple birth to mother and offspring are well known. The maternal mortality as well as the stillbirth and infant mortality rates associated with twin deliveries are three times as high as those relating to single births (1, 2). In this sense multiple births may be considered abnormal, or in the words of Newman (3), "the human uterus is of the simplex or undivided type and is adapted for the really satisfactory gestation of but one fetus at a time. When two or more fetuses come to occupy the space usually filled by one, the twins, whether of the one-egg or two-egg type, crowd each other and compete for the common food supply." In addition, the presence of two or more fetuses presents in many cases more complicated obstetrical problems. Guttmacher (1, 4), on the basis of his studies and a review of the literature, shows that abnormal presentations and complications of pregnancy, labor and delivery are more frequent among multiple deliveries than among single births. The problem of multiple births, therefore, is of interest not only to the biologist, but also to the obstetrician and to the public health worker.

Twins are generally distinguished into two major types: The monozygotic or identical, where presumably a single ovum produces two offspring; and the dizygotic or fraternal, in which the two offspring result from two ova. That the two types of twins represent two distinct manifestations of the twinning process has been demonstrated by the investigations of Weinberg (5), Dahlberg (6), Greulich (7), and Guttmacher (8). These studies show that the probability of giving birth to identical twins does not vary with age and parity of mother, while the

[1] From the Division of Public Health Methods, National Institute of Health, U. S. Public Health Service, and the Division of Maternity, Infancy and Child Hygiene, New York State Department of Health.

frequency of fraternal twins increases continuously with mother's age and parity. In the preceding paper of this series (9), it was shown that the increase in the frequency of dizygotic twins is independently related to the factors of age and parity, but that it is more closely related to parity than to age of mother. There is also evidence from Weinberg's and Dahlberg's studies that the fetal mortality is higher among monozygotic than among dizygotic twins. It is the object of the present paper to study in more detail the early mortality of twins, that is, their stillbirth and neonatal mortality rates.

MATERIAL AND METHOD

The present study is based partly on the published data of the Division of Vital Statistics of the Bureau of the Census (10) and partly on the Vital Statistics records of New York State (exclusive of New York City). Most of the findings on stillbirths concern the births over the five-year period (1931-1935) in the United States Birth Registration Area. Data for the births of two years (1936-1937) in New York State are used to supplement these results by adding information on neonatal mortality and on the factors of age and parity of mother which are not available for the entire country. The information on neonatal mortality was obtained by matching the death and birth certificates belonging to the same infant. Likewise, the certificates of two members of a pair of twins were matched.

From information available on birth certificates it is impossible to differentiate between the two types of twins. The only distinction that can be made is whether or not two members of a pair are of the same or different sex. Hence, in the following analysis the twins are divided into these two major types. In addition, an approximation to the classification of identical and fraternal twins is attempted by an extension of Weinberg's Differential Method (5, 11). By Weinberg's method the distribution of the two types of twins is obtained by subtracting from each group of like-sexed twins a number equal to that of unlike-sexed twins in the same classification. The distribution of the remainder, supposedly, is that of identical twins. In a similar manner it may be possible to obtain the mortality rates of identical and fraternal twins. For example, if there were N_1 like-sexed twins of whom S_1 were stillborn, and N_2 unlike sexed twins of whom S_2 were stillborn, then the stillbirth rate of identical twins would be $\frac{S_1 - S_2}{N_1 - N_2}$ while the stillbirth rate of fraternal twins would be $\frac{S_2}{N_2}$. The assumption involved in this pro-

cedure is that like-sexed dizygotic twins and unlike-sexed twins do not differ materially in their mortality with respect to the various factors studied. There is no apparent reason to doubt the validity of this assumption. However, even if this assumption is not strictly justified, it is still possible to obtain broad differences between the two types of twins by comparing the like-sexed and the unlike-sexed groups. It may be added, also, that the results obtained by Weinberg's Differential Method in the preceding paper of this series (9) agree well with the findings of Greulich and of Guttmacher who used direct methods for classifying the twins. This adds confidence to the method as a valuable tool for studying the two types of twins.

STILLBIRTH RATE OF TWINS

In the 5-year period, 1931-1935, there occurred in the United States Birth Registration Area a total of 126,401 twin deliveries; that is, 252,802 individual twins born. Of these, 19,589 were stillbirths. This gives a stillbirth rate of 77.5 per 1,000 twins, which is more than twice as high as the stillbirth rate for all births in the same period (35.7). During the same 5-years there occurred 1,253 deliveries of triplets, or 3,759 individual triplets, of whom 572 were stillborn. The stillbirth rate for triplets was, therefore, 152.2, or nearly twice as high as that of twins and over four times as high as the rate for total births. One important contributing factor to the high stillbirth rate of twins and triplets is premature birth for which the stillbirth rate is very high. Information on this point for the entire country is not available. According to data from New York State it appears that while only one in every twenty deliveries of single births terminated prematurely, more than one in every four multiple deliveries was premature. Premature birth, however, is not the only factor responsible for the high stillbirth rates of multiple births; the stillbirth rate is also higher among multiple births than among single births when the premature are excluded and comparison is made between the full-term births only (12).

The distribution of the twin deliveries by sex was as follows: In 42,923 cases both members of a pair were males; in 40,848 cases both were females; in 42,557 cases one was a male and one was a female, and in 73 cases the sex was unknown. The stillbirth rate in the group of two males was 89.8; in the group of two females it was 74.3; and in the unlike-sexed group the rate was 66.5. The higher stillbirth rate for the group of two males over that of two females is not unexpected,

since it is not different from the known excess of the stillbirth rate of male infants over that of female infants for all births. For example, in the same period the stillbirth rate for all males in the same area was 38.6, while that of all females was 31.1—that is, for all births the stillbirth rate for males was higher by 24 percent than that of females. The interesting finding is that *the stillbirth rate of the group of one male and one female twin was lower than that of the group of two female twins.* The stillbirth rate in the group of like-sexed twins was 82.3, or nearly 24 percent higher than the rate in the group of unlike-sexed twins. Since the like-sexed groups consist of both identical and fraternal twins, while the unlike-sexed twins are fraternal,[2] it appears that *the stillbirth rate for monozygotic twins is higher than that of dizygotic twins.* If the assumption is true that the like-sexed fraternal twins are as numerous as unlike-sexed twins, and that the stillbirth rate of these two groups of dizygotic twins are not materially different, then the stillbirth rate of identical twins would be 98.6 or 50 percent higher than that of fraternal twins. French statistics quoted by Dahlberg (6) give the percentage of deaths at birth as 24.3 for monozygotic and 12.7 for dizygotic twins.

The excess in the stillbirth rate of like-sexed over that of unlike-sexed twins was due almost entirely to the relatively larger number of deliveries in which both members of a pair were stillborn. Deliveries in which one member of a pair was born alive and the other stillborn were proportionately as numerous among the unlike-sexed as among the like-sexed twins. Of 83,771 deliveries of like-sexed twins, 73,938 (88.3 percent) were of two live births; 5,881 (7.0 percent) were of one live birth and one stillbirth; and 3,952 (4.7 percent) were of two stillbirths. The corresponding figures for unlike-sexed twin deliveries were as follows: Of 42,557 deliveries, both members were born alive in 38,178 (89.7 percent) cases; one live birth and one stillbirth occurred in 3,100 (7.3 percent) cases; and in 1,279 (3.0 percent) cases both members of a pair were stillborn. The proportion of deliveries of two stillbirths was, therefore, higher by over 50 percent in the group of like-sexed twins than among the unlike-sexed twins. If the procedure described above is used for isolating the identical twins from among the like-sexed, Table 1 is obtained.

[2] There are rare reports in the literature of unlike-sexed twins which may not be dizygotic, but it is generally agreed that practically all unlike-sexed twins are fraternal.

TABLE 1

Twin deliveries of one live birth and one stillbirth and deliveries of two stillbirths, United States Birth Registration Area, 1931-1935

TYPE OF TWINS	NUMBER OF DELIVERIES	DELIVERIES OF ONE LIVE BIRTH AND ONE STILLBIRTH		DELIVERIES OF TWO STILLBIRTHS	
		Number	Percent	Number	Percent
Monozygotic*	41,214	2781	6.7	2673	6.5
Dizygotic*	85,114	6200	7.3	2558	3.0

* Obtained by Weinberg's Differential Method.

The proportion of deliveries in which both members were stillborn was twice as large among monozygotic twins as among dizygotic, while there was little difference between the two types of twins in the proportion of cases in which one member of a pair was a stillbirth and the other a live birth. In this connection, it is interesting to note that there are greater intra-pair differences in weight and length at birth among identical twins than among fraternal twins (see Guttmacher, 1). This finding may be interpreted as suggesting that the higher proportion of deliveries of two stillbirths among identical twins cannot be explained in terms of similarity of weight.

Among other factors which may be related to the mortality of monozygotic and dizygotic twins, parity and age of mother should be considered. As was stated above, the frequency of fraternal twins increases with both these factors while the frequency of identical twins by parity and age of mother is nearly constant. The stillbirth rate also increases with advancing parity and age of mother (12). It would therefore be of interest to compare the mortality of the two types of twins in the various birth orders and in the different age groups of mother. It would also be desirable to determine the differences in the neonatal mortality of the two types of twins, since the stillbirth rate is, probably, more influenced by obstetrical factors than the neonatal mortality rate. Information on these points for the entire country is not available. Use will therefore be made, in the following, of the records of the New York State Department of Health.

The stillbirth rates according to sex of twins in New York State paralleled those of the entire country. In the two-year period 1936-1937, there occurred in New York State, exclusive of New York City, a total of 1,830 twin deliveries among 166,120 total births. Of the 3,660 individual twins, 197 were stillborn. The stillbirth rate of twins in New York State was 53.8 per 1,000 twins. This is considerably lower than the stillbirth rate for twins in the United States Birth Registration Area. However, the total stillbirth rate in New York State was also lower than that of the country.

The distribution of twin deliveries by sex in New York state was as follows: 632 pairs were of two males; 642 were of two females; and 556 were of unlike sex. The stillbirth rates in these three groups were 66.5, 55.3, and 37.8, respectively. That is, in New York State as well as in the entire country the rate was highest in the group of two males and lowest in the group of unlike-sexed twins. Here again the difference occurred among the deliveries in which both twins were stillborn. In the like-sexed group, 39, or 3 percent, of the 1,274 deliveries were of two stillbirths. In the case of unlike-sexed twins, of 556 deliveries only in 5, or 1 percent, were both members born dead.

Information on neonatal mortality (death of infants under 1 month of age) is available only for the births of the year 1936. Of the 918 pairs of twins born in 1936, in twenty-one cases both members of a pair were stillbirths, and in 56 cases one was a stillbirth and the other a live birth. Of the remaining 1,738 individual twins who were born alive, 212 died before they were one month old. The neonatal mortality rate among twins was, therefore, 122.0 per 1,000 live twins. This rate was more than four times as high as the neonatal mortality for all the births in that area in the same year.

The neonatal mortality of like-sexed was higher than that of unlike-sexed twins. Of the twins in which the two members of a pair were born alive the neonatal mortality rate among like-sexed twins was 123.3 and that of unlike-sexed twins was 102.4. The Differential Method gives a neonatal mortality rate of 138.5 for monozygotic twins. Here again the difference occurred among twins in which both members died neonatally. Thus out of 592 like-sexed pairs of twins in which both were born alive, in 53 cases both members of a pair died under one month of age and in 40 cases one was a neonatal death and the other survived the first month of life. Of the 249 unlike-sexed pairs of twins in which both were born alive, in 18 cases both were neonatal deaths and in 15 cases one died neonatally and the other survived. The percentage of

TABLE 2

Stillbirth rates of twins by sex of twin and order of birth, New York State (exclusive of New York City) 1936-1937

ORDER OF BIRTH	NUMBER OF TWINS					NUMBER OF STILLBIRTHS					STILLBIRTH RATES*				
	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	Unlike-sexed	Like-sexed	Monozygotic‡	Dizygotic‡
Total	3660	1264	1284	1112	2548	197	84	71	42	155	53.8	37.8	60.8	78.7	37.8
1	958	346	366	246	712	56	29	20	7	49	58.5	28.5	68.8	90.1	28.5
2	866	292	328	246	620	45	20	21	4	41	52.0	16.3	66.1	98.9	16.3
3	576	204	196	176	400	24	9	8	7	17	41.8	39.8	42.5	44.6	39.8
4	382	136	118	128	254	27	11	12	4	23	70.7	31.3	90.6	150.8	31.3
5	240	82	72	86	154	12	5	2	5	7	50.0	58.1	45.5	29.4	58.1
6 and over	636	202	204	230	406	33	10	8	15	18	52.0	65.2	44.3	17.1	65.2
Not stated	2	2	...	...	2	..	..								

* Per 1,000 twins in each category.
‡ Obtained by Weinberg's Differential Method.

cases in which both died was 9.0 for the like-sexed and 7.2 for the unlike-sexed, while the respective percentages for cases in which one member died and the other survived were 6.8 and 6.0. Although no definite conclusions can be deduced from any of the differences given above since the number of cases is small and the differences are not statistically significant, it is indicated that also in neonatal mortality as in stillbirths, monozygotic twins may have higher rates than dizygotic and that the excess is accounted for by a larger proportion of cases in which both members of a pair died.

ORDER OF BIRTH AND AGE OF MOTHER

Table 2 presents the distribution of the 3,660 twins according to their order of birth and sex and the number of stillbirths in each category. In addition, the table presents stillbirth rates of like-sexed and unlike-sexed twins as well as the rates for monozygotic and dizygotic twins as obtained by the Differential Method. The order of birth of the two members of a pair of twins was taken as that of the one born first.

Several interesting facts appear in this table; in the first place, the stillbirth rate of all twins does not appear to vary greatly with order of birth. The stillbirth rate for all births, as is known, varies considerably with the factor of order of birth; it is generally high for first births, at a minimum for second births and is very high for the higher orders of birth. In the case of all twins the rate was nearly constant for all orders of birth. There was a difference in the variation of the stillbirth rate between the like-sexed and the unlike-sexed twins. Among the former the stillbirth rate tended to decrease with advancing order of birth while among the unlike-sexed twins there was a noticeable increase of the rate with advancing order of birth. As a consequence the stillbirth rate of monozygotic twins of the first four orders of birth is considerably higher than the rate for dizygotic twins, while in the twins of birth orders 5 and over the situation is reversed, the rate being higher for the fraternal than for the identical twins.

The variation of the stillbirth rate of twins with age of mother is shown in Table 3. Also, in this case the stillbirth rate of twins did not vary with age of mother as markedly as the stillbirth rate for all births. The rate for like-sexed twins was higher than that of unlike-sexed twins in practically all age groups of mother. When the unlike-sexed were subtracted out of the like-sexed twins the stillbirth rate for monozygotic

TABLE 3

Stillbirth rates of twins by sex of twins and by age of mother, New York State, (exclusive of New York City) 1936-1937

AGE OF MOTHER	NUMBER OF TWINS					NUMBER OF STILLBIRTHS					STILLBIRTH RATES*			
	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	Unlike-sexed	Like-sexed	Monozygotic‡	Dizygotic‡
Total	3660	1264	1284	1112	2548	197	84	71	42	155	53.8	37.8	60.8	78.7	37.8
Under 20	176	64	70	42	134	12	6	4	2	10	68.2	47.6	74.6	87.0	47.6
20-24	894	328	364	202	692	45	18	21	6	39	50.3	29.7	56.4	67.4	29.7
25-29	1054	364	360	330	724	68	29	26	13	55	64.5	39.4	76.0	106.6	39.4
30-34	848	276	284	288	560	34	14	12	8	26	40.1	27.8	46.4	66.2	27.8
35-39	534	186	168	180	354	22	8	6	8	14	41.2	44.4	39.6	34.5	44.4
40 and over	154	46	38	70	84	16	9	2	5	11	103.9	71.4	130.9	428.6	71.4

* Per 1,000 twins in each category.
‡ Obtained by Weinberg's Differential Method.

TABLE 4

Frequency of prematurity among twin deliveries by order of birth and sex of twins, New York State (exclusive of New York City) 1936-1937

ORDER OF BIRTH	NUMBER OF TWIN DELIVERIES					NUMBER OF PREMATURE TWIN DELIVERIES					FREQUENCY OF PREMATURE TWIN DELIVERIES*				
	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	Unlike-sexed	Like-sexed	Monozygotic‡	Dizygotic‡
Total	1830	632	642	556	1274	541	201	204	136	405	295.6	244.6	317.9	374.7	244.6
1	479	173	183	123	356	190	77	77	36	154	396.7	292.7	432.6	506.4	292.7
2	433	146	164	123	310	119	44	45	30	89	274.8	243.9	287.1	315.5	243.9
3	288	102	98	88	200	78	22	32	24	54	270.8	272.7	270.0	267.9	272.7
4	191	68	59	64	127	43	18	15	10	33	225.1	156.3	259.8	365.1	156.3
5	120	41	36	43	77	25	8	11	6	19	208.3	139.5	246.8	382.4	139.5
6 and over	318	101	102	115	203	86	32	24	30	56	270.4	260.8	275.9	295.5	260.9
Not Stated	1	1	...	...	1	...	...	...	...	...	....	....	....	....	....

* Per 1,000 twins in each category.

‡ Obtained by Weinberg's Differential Method.

twins was found to be considerably higher than that of dizygotic in practically every age group.

Premature birth: The frequency of premature birth is one of the important contributing factors to the high stillbirth and neonatal mortality rates of twins. It is, therefore, of interest to investigate the differences in the two types of twins with respect to the factor of prematurity. Of the 1,830 twin deliveries in New York State, 541 or nearly 30 percent were premature.[3] Among the 1,274 deliveries of like-sexed twins 405 were premature, and 136 of the 556 deliveries of unlike-sexed twins were premature. The frequency of prematurity per 1,000 deliveries was 317.9 among the like-sexed and 244.6 among the unlike-sexed. The frequency of prematurity among monozygotic twins as obtained by the Differential Method was 374.7, which was higher by over 50 percent than that among dizygotic twins.

The frequency of premature deliveries among all the births is known to vary considerably with the factors of parity and age of mother. The variation is of the U-shape pattern with high frequencies among first births and births of high orders and low frequencies for the intermediary orders of birth. Similarly the frequency is high for births to young and old mothers and relatively low when the mother is between 20 and 30 years of age (12). In order to determine whether or not the frequency of prematurity among twin deliveries varies in a similar way, and whether the excess in the frequency of premature birth among deliveries of monozygotic twins is present in all orders of birth and age groups of mother Tables 4 and 5 are presented.

It may be noticed that the frequency of premature birth among twins did not increase with advancing birth order and age of mother. In fact the tendency is towards higher frequencies among first births and young mothers and lower frequencies among the higher birth orders and the older mothers. This was true for both like-sexed and unlike-sexed twins. The increase in frequency of premature births among like-sexed over that of unlike-sexed twins was present in practically every order of birth and every age group of mother.

In summing up the findings thus far it appears that the stillbirth rate of monozygotic twins is considerably higher than that of dizygotic twins, and that the excess is due primarily to a relatively larger proportion of births in which *the two members of a pair* are stillborn. The

[3] Prematurity was determined from the physician's statement on the birth and stillbirth certificates.

TABLE 5

Frequency of prematurity among twin deliveries by age of mother and sex of twins, New York State (exclusive of New York City) 1936-1937

AGE OF MOTHER	NUMBER OF TWIN DELIVERIES					NUMBER OF PREMATURE TWIN DELIVERIES					FREQUENCY OF PREMATURE TWIN DELIVERIES*				
	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	2 males	2 females	1 male 1 female	Total like-sexed	All twins	Unlike-sexed	Like-sexed	Monozygotic‡	Dizygotic‡
Total	1830	632	642	556	1274	541	201	204	136	405	295.6	244.6	317.9	374.7	244.6
Under 20	88	32	35	21	67	36	14	13	9	27	409.1	428.6	403.0	391.3	428.6
20-24	447	164	182	101	346	152	52	69	31	121	340.0	306.9	349.7	367.4	306.9
25-29	527	182	180	165	362	139	58	55	26	113	263.8	157.6	312.2	441.6	157.6
30-34	424	138	142	144	280	121	41	43	37	84	285.4	256.9	300.0	345.6	256.9
35-39	267	93	84	90	177	73	27	21	25	48	273.4	277.8	271.2	264.4	277.8
40 and over	77	23	19	35	42	20	9	3	8	12	259.7	228.6	285.7	571.4	228.6

* Per 1,000 twins in each category.

‡ Obtained by Weinberg's Differential Method.

higher stillbirth rate of monozygotic twins was found to be present in practically all orders of birth and age groups of mother. There is also some indication that the same condition is true in neonatal mortality. One contributing factor to these high rates is premature birth which is more frequent among monozygotic than among dizygotic twins. It may be added that there is some evidence (2) that puerperal fatality [4] may also be higher among mothers of monozygotic than among mothers of dizygotic twins, although it could not be established conclusively due to the small number of cases available for study.

CONSTITUTIONAL AND ENVIRONMENTAL FACTORS IN STILLBIRTHS

Twins have been used extensively in studies concerning the hereditary and environmental manifestations of various traits and pathological conditions. The usual procedure in such studies consists of observations on two sets of twins—identical and fraternal—in which at least one member of a pair has the particular condition. If it is observed that the *two members of a pair* exhibit the condition under investigation more often among identical than among fraternal twins, the conclusion is reached that the condition, or a tendency towards the condition is, at least in part, inherited. The assumption involved in this conclusion is that the effect of the environmental factor is the same for both types of twins and the only variable involved is the constitutional one since both members of a pair of identical twins presumably have the same biological constitution.

The same method may be employed in studying environmental and constitutional factors causing stillbirth. According to this method, the conditions causing stillbirth may be thought of as falling broadly into two main groups. The first group includes those due to environmental factors, which would embrace such considerations as variations in obstetrical techniques, quality of prenatal care, and the like. The second group is composed of conditions due to constitutional factors—that is, that the fetus is constitutionally inferior and lacking in vitality. The assumption would be that the first group of factors is similar for the two types of twins and that the difference between the two types of twins in the pro-

[4] The term "puerperal fatality" was defined in (2) as the risk of death to the mother associated with the delivery of an offspring of viable age. It is measured by a "puerperal fatality rate" defined as the number of deaths of mothers who were delivered either of a live birth or of a stillbirth per 1,000 total deliveries (including those of stillbirths).

portion of deliveries in which the two members of a pair were stillborn would indicate the strength of the second factor.

From Table 1 it is seen that there were 5,454 pairs of identical twins and 8,758 pairs of fraternal twins in which at least one member was stillborn. These deliveries were distributed as follows:

Type of twin	*Deliveries of which at least one member of a pair was a stillbirth*	*Deliveries of two stillbirths*	*Percent concurrence*
Monozygotic	5454	2673	49.0
Dizygotic	8758	2558	29.2

The higher proportion of concurrence among the monozygotic twins (49.0 percent) than among the dizygotic twins (29.2 percent) presumably indicates the strength of the constitutional factor. There are, however, at least two considerations which may impose limitations on this conclusion. In the first place the method assumes that the intra-uterine environment is the same for both types of twins. It is true that the observable differences such as the intra-pair differences in weight and length would tend towards a larger proportion of concurrence of deaths among the dizygotic twins. But there may be other differences in the intra-uterine environment between the two types of twins which may be responsible for the larger proportion of deliveries of two stillbirths among the monozygotic twins. The second consideration is the fact that there were proportionately more monozygotic pairs of twins where at least one member was a stillbirth than there were in the dizygotic group, as may be seen from the following table:

Type of twin	*Number of twin deliveries*	*Twin deliveries with at least one stillbirth*	
		Number	Percent
Monozygotic	41,214	5454	13.2
Dizygotic	85,114	8758	10.3

Thus in 13.2 percent of all monozygotic twin deliveries at least one member of a pair was a stillbirth, while only 10.3 percent of the dizygotic twin deliveries were of at least one stillbirth. The difference in these percentages is statistically significant. It is, therefore, possible that the monozygotic twins may be constitutionally inferior to dizygotic twins and hence the two groups are not strictly comparable. It should also be noted that these limitations are not restricted to the problem of constitutional and environmental conditions causing stillbirths, but that they

apply equally to most other investigations on nature and nurture in which this method is used.

MORTALITY OF FIRST VERSUS SECOND TWIN

Because the first born of a pair of twins presumably receives the greater trauma during labor it has been generally assumed that the stillbirth rate is higher among the first than among the second twin. Peckham (13) shows that such is not the case. In fact in his series it is shown that in the same weight groups the rates tend to be lower for the first of a pair of twins. The difference between his rates for first and second twins are not statistically significant due to the relatively small number of pairs of twins available for study. From the material of New York State it is possible to investigate this question on a larger series of births.

The order in which the two members of a pair were born was determined from the statements of hour of birth on the birth and stillbirth certificates. It was thus possible to obtain stillbirth rates separately for the members of the twins who were born first and for those who were born second. The stillbirth rate was significantly lower for the first twin than for the second. The respective rates were 45.4 and 62.8. The difference between the rates becomes more pronounced when the cases in which both members of a pair were stillborn are excluded. Of the 109 pairs in which one was stillborn and the other born alive, the first was a stillbirth in only 38, or 34.9 percent, of the cases, and the second was born dead in 71, or 65.1 percent.

The advantage to the first of a pair of twins was pronounced both in the like-sexed and the unlike-sexed groups. The difference in the rates between the two members of a pair was more marked in the unlike-sexed twins than in the like-sexed. The rate for the first twin in the unlike-sexed group was 25.2 and the rate for the second twin was 50.4. In the like-sexed group the corresponding rates were 53.4 and 68.3.

That the explanation for the higher rates of the second of a pair of twins may probably be found in obstetrical considerations is indicated by the fact that the neonatal mortality rates of twins did not differ significantly between the first and second members of a pair. In fact, there was a slight advantage to the *second* of a pair of twins. Of the 55 sets of twins in which one was a neonatal death and the other survived the first month of life, 31 of the first twins and 24 of the second twins died neonatally. In the cases in which one member of a pair was a still-

birth and the other a live birth, the neonatal mortality rate among the live-born was the same for the second as it was for the first twin. Thus, of the 56 live births whose partners were stillbirths, 37 were first twins and 19 were second twins. Of the 37 first twins, 10, or 27 percent, were neonatal deaths. Among the 19 second twins there were five, or 26 percent, neonatal deaths. These figures are, of course, small but they indicate first that the neonatal mortality rate of members of a pair of twins whose partners were stillborn is very much higher than that of twins in which both members were born alive. They also indicate that the handicapping of the second of a pair of twins is present only among the stillbirths, while the neonatal mortality of the second of a pair of twins is not higher than that of the first twin both when its partner was a stillbirth and when he survived the neonatal period.

SUMMARY

This paper deals with the late fetal and neonatal mortality of twin deliveries. It is based partly on the births for a five-year period (1931-1935) in the United States Birth Registration Area and partly on the births for a two-year period (1936-1937) in New York State (exclusive of New York City). The following findings are recorded:

(1) The stillbirth and neonatal mortality rates of twins is more than three times as high as those of single births.

(2) The stillbirth and neonatal mortality rates of like-sexed are considerably higher than those of unlike-sexed twins. This excess is due to a larger proportion of twin deliveries in which both members succumb among like-sexed than among unlike-sexed twins.

(3) The stillbirth rate of like-sexed twins is higher than that of unlike-sexed twins in practically every order of birth and age group of mother. The stillbirth rate of twins does not increase with advancing age and parity of mother.

(4) Nearly 30 percent of twin deliveries are premature. The frequency of premature deliveries is higher among like-sexed than among unlike-sexed twin births.

(5) The second of a pair of twins is exposed to a greater risk of a stillbirth than the first twin. The neonatal mortality rate for twins is not significantly different betwen the first and second members of a pair.

(6) The implication of the difference in the stillbirth rates among monozygotic and dizygotic twins is discussed in light of the use made of twins in studies on nature and nurture.

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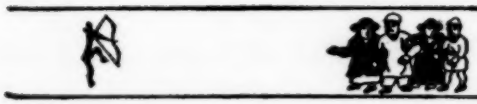

THE STANDARD ERROR OF THE SLOPE OF A STRAIGHT LINE[1]

BY JOSEPH F. KISH

INTRODUCTION

IN THE evaluation of the standard error of the slope constant of a fitted straight line it is necessary to distinguish between two kinds of data; first, where nothing whatever is known about the law of variation to which the individual observed points conform, and secondly, where the distribution for each observed point is known.

In all that follows it is assumed that the x values are fixed, in the sense of not being subject to fluctuations of sampling, and that all of the variation is in the y determinations.

Van Uven [2] has obtained the standard error of the slope constant for the case where nothing is known about the variations of the individual points. Utilizing his approach to the problem, and without making any changes in the mathematical treatment (other than equating all weighting factors to unity), the writer was able to extend his method to the case where the law of variation is known for each observed point. Van Uven did not introduce into his demonstration the hypothesis that the variation in a particular ordinate, about its hypothetical *true* value, is to be considered as conforming to the normal equation; but, by introducing the assumption of normality into Van Uven's case and into our own, we were able to calculate the values of the third and fourth moments for each of the two distributions of slope constants. Both distributions turned out to be normal. Of course, any assumption which makes the distribution of an individual observed point about its *true* value other than a normal one would introduce difficulties into the calculation of

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[2] Van Uven, M. J. Mathematical Treatment of the Results of Agricultural and Other Experiments. *Groningen* and *Batavia* (P. Noordhoff N.V.) 1935, pp. 74-81.

the third and fourth moments, and it is fairly certain that the resulting distribution of the slope constants would not be normal. In such a case any test for the significance of the difference between a pair of slope constants would have to be revised, and at considerable labor, each time that a new functional form was introduced to describe the variation of an individual observed point.

What follows in this paper is divided into three sections. In the first is reproduced Van Uven's derivation of the standard error. While it is true that his least square solution for the constants of the straight line ($y = a + bx$) is not carried out in the customary least square manner, due to the strictness with which he avoids use of the calculus, we did not see fit to make any alterations in a demonstration that could hardly be improved upon with respect to simplicity and clarity. Our second section contains the analysis leading to the equations for the second, third, and fourth moments of the distribution of slope constants. Here the assumption is that for every point, such as (x_K, y_K), repeated measurements would yield a set of values for the y_K ordinate which would distribute normally about the one value of y_K that we actually do possess, and with a known standard error. The last section of this paper is taken up with the results of the two separate sampling checks, each comprising 750 fitted straight lines.

VAN UVEN'S DERIVATION OF THE STANDARD ERROR OF THE SLOPE CONSTANT

Setting

$$V_K = y_K - bx_K - a \tag{1}$$

we must select a and b so that ΣV_K^2 is a minimum. Shift the origin of x and y to X and Y, and put

$$x_K = X + a_K, \; y_K = Y + \beta_K$$

so that V_K becomes

$$V_K = (Y - bX - a) + \beta_K - ba_K$$

or, when n equals the number of observed points,

$$\sum_K V_K^2 = n(Y - bX - a)^2 + 2(Y - bX - a)\left(\sum_K \beta_K - b\sum_K a_K\right) + \sum_K \beta_K^2 - 2b\sum_K a_K\beta_K + b^2\sum_K a_K^2. \tag{2}$$

Selecting X and Y so that $\sum_K a_K = 0$, and $\sum_K \beta_K = 0$ gives

$$X = \bar{x} = \frac{\sum_K x_K}{n} \text{ and } Y = \bar{y} = \frac{\sum_K y_K}{n}$$

where $\bar{x}$ represents the mean of all x's and $\bar{y}$ the mean of all y's.

Setting

$$u_K = x_K - \bar{x} \text{ and } v_K = y_K - \bar{y} \tag{3}$$

then a_K and β_K become u_K and v_K respectively, and equation (2) can be written

$$\sum_K V_K^2 = n(\bar{y} - b\bar{x} - a)^2 + (\sum_K v_K^2 - 2b\sum_K u_K v_K + b^2 \sum_K u_K^2). \tag{4}$$

The minimum value of the first term on the right is zero, therefore we must put

$$\bar{y} - b\bar{x} - a = 0. \tag{5}$$

In other words the fitted line must go through $(\bar{x}, \bar{y})$.

Equation (4) now becomes

$$\sum_K V_K^2 = \sum_K u_K^2 \left(b - \frac{\sum_K u_K v_K}{\sum_K u_K^2} \right)^2 + \sum_K v_K^2 - \frac{(\sum_K u_K v_K)^2}{\sum_K u_K^2}. \tag{6}$$

The first term on the right is always positive, so that its minimum value is zero, giving

$$b = \frac{\sum_K u_K v_K}{\sum_K u_K^2} = \bar{b}. \tag{7}$$

From (5)

$$a = \bar{y} - \bar{b}\bar{x} = \bar{y} - \frac{\sum_K u_K v_K}{\sum_K u_K^2} \bar{x} = \bar{a}. \tag{8}$$

The least square solution therefore gives for a and b the values of $\bar{a}$ and $\bar{b}$.

Now let

$$U_K = y_K - \bar{b}x_K - \bar{a}, \tag{9}$$

and have then

$$\sum_K U_K = n\bar{y} - \bar{b}n\bar{x} - n\bar{a} = n(\bar{y} - \bar{b}\bar{x} - \bar{a}) = 0.$$

Since $\sum_K U_K^2$ is the minimum value of $\sum_K V_K^2$, equation (6) becomes

$$\sum_K U_K^2 = \sum_K v_K^2 - \frac{(\sum_K u_K v_K)^2}{\sum_K u_K^2}. \tag{10}$$

Let $\hat{y}_K$ represent the *true* value of y_K, and η_K its *true* error, so that

$$y_K = \hat{y}_K + \eta_K.$$

From

$$v_K = y_K - \bar{y} = y_K - \frac{\sum_K y_K}{n}$$

follows for the true error Δv_K of v_K

$$\Delta v_K = \eta_K - \frac{\sum_K \eta_K}{n}. \tag{11}$$

Equation (7) gives for the true error Δb of b

$$\Delta b = \frac{\Delta(\sum_K u_K v_K)}{\sum_K u_K^2} = \frac{\sum_K u_K \Delta v_K}{\sum_K u_K^2}.$$

Now

$$\sum_K u_K \Delta v_K = \sum_K u_K \eta_K - \frac{(\sum_K u_K)(\sum_K \eta_K)}{n} = \sum_K u_K \eta_K.$$

In the following discussion the symbols $[\![\ ]\!]$ enclosing an expression denote the mean or asymptotic value of a very large number of samples.

$$\left[\!\!\left[(\sum_K u_K \Delta v_K)^2 \right]\!\!\right] = \left[\!\!\left[(\sum_K u_K \eta_K)^2 \right]\!\!\right] = \sum_K u_K^2 \left[\!\!\left[\eta_K \cdot \eta_K \right]\!\!\right] + 2 \sum_{K} \sum_{L} u_K u_L \left[\!\!\left[\eta_K \cdot \eta_L \right]\!\!\right]$$

At this point Van Uven notes that $[\![\eta_K \cdot \eta_L]\!]$ vanishes for all values of K and L, because y_K and y_L were observed independently of one another. To make that statement correct it is necessary to bring out an assumption implicit in Van Uven's reasoning—namely, that η_K and η_L assume plus and minus values with zero as a mean. If two or more of the η distributions were skew and measured about the mode as origin, then $[\![\eta_K \cdot \eta_L]\!]$ would not vanish for all values of K and L. Granting that η_K, for all values of K, is measured about zero as a mean, and

representing $[\![\eta_K \cdot \eta_K]\!]$ by σ^2, for all κ values, the preceding equation gives

$$[\![(\sum_K u_K \Delta v_K)^2]\!] = \sigma^2(\sum_K u_K^2).$$

Then

$$\sigma_{\bar{b}}^2 = [\![\Delta\bar{b} \cdot \Delta\bar{b}]\!] = \frac{[\![(\sum_K u_K \Delta v_K)^2]\!]}{(\sum_K u_K^2)^2} = \frac{\sigma^2}{\sum_K u_K^2}. \qquad (12)$$

We have yet to determine σ^2. Distinguishing between $\bar{a}$ and $\bar{b}$, the least square constants for the one set of observed points that we do possess; and a_0 and b_0, the two constants of the hypothetical *true* line, we have

$$\eta_K = y_K - b_0 x_K - a_0. \qquad (13)$$

Equation (4) gives

$$\sum_K \eta_K^2 = n(\bar{y} - b_0\bar{x} - a_0)^2 + (\sum_K v_K^2 - 2b_0 \sum_K u_K v_K + b_0^2 \sum_K u_K^2),$$

or

$$\sum_K \eta_K^2 = n(\bar{y} - b_0\bar{x} - a_0)^2 + \sum_K u_K^2 \left(b_0 - \frac{\sum_K u_K v_K}{\sum_K u_K^2} \right)^2 + \left(\sum_K v_K^2 - \frac{(\sum_K u_K v_K)^2}{\sum_K u_K^2} \right). \qquad (14)$$

Now

$$\bar{b} = b_0 + \Delta\bar{b}, \text{ and } \bar{a} = a_0 + \Delta\bar{a},$$

hence by (8)

$$\bar{y} - b_0\bar{x} - a_0 = \bar{y} - \bar{b}\bar{x} - \bar{a} + \Delta\bar{b} \cdot \bar{x} + \Delta\bar{a} = 0 + \Delta\bar{y},$$

and

$$b_0 - \frac{\sum_K u_K v_K}{\sum_K u_K^2} = b_0 - \bar{b} = -\Delta\bar{b},$$

so that (14) gives, with the aid of (10),

$$\sum_K \eta_K^2 = n(\Delta\bar{y})^2 + \sum_K u_K^2 (\Delta\bar{b})^2 + \sum_K U_K^2.$$

Then

$$\left[\!\left[\sum_K \eta_K^2\right]\!\right] = n\left[\!\left[(\Delta\bar{y})^2\right]\!\right] + \sum_K u_K^2 \left[\!\left[(\Delta b)^2\right]\!\right] + \left[\!\left[\sum_K U_K^2\right]\!\right],$$

and

$$\left[\!\left[\sum_K \eta_K^2\right]\!\right] = n\sigma^2 = n \cdot \frac{\sigma^2}{n} + \left(\sum_K u_K^2\right)\left(\frac{\sigma^2}{\sum_K u_K^2}\right) + \left[\!\left[\sum_K U_K^2\right]\!\right]$$

$$= 2\sigma^2 + \left[\!\left[\sum_K U_K^2\right]\!\right].$$

Hence

$$(n-2)\sigma^2 = \left[\!\left[\sum_K U_K^2\right]\!\right]. \tag{14a}$$

Replacing the unknowable $\left[\!\left[\sum_K U_K^2\right]\!\right]$ by the only estimate of it that we have, namely $\sum_K U_K^2$, we get

$$\sigma^2 \simeq \frac{\sum_K U_K^2}{n-2} = \frac{\sum_K v_K^2 - \dfrac{(\sum u_K v_K)^2}{\sum_K u_K^2}}{(n-2)}. \tag{15}$$

Equation (12) now gives

$$\sigma_b^2 \simeq \frac{\sum_K U_K^2}{(n-2)\sum_K u_K^2} = \frac{\sum_K v_K^2 - \dfrac{(\sum u_K v_K)^2}{\sum_K u_K^2}}{(n-2)\sum_K u_K^2}. \tag{16}$$

At this point it is well to write out the three expansions that we shall use in evaluating the second and higher moments:

$$\left(\sum_K u_K\eta_K\right)^2 = \sum_K u_K^2\eta_K^2 + 2\sum_{KL}\sum u_K u_L \eta_K \eta_L \tag{17}$$

$$\left(\sum_K u_K\eta_K\right)^3 = \sum_K u_K^3\eta_K^3 + 3\sum_{KL}\sum u_K^2 u_L \eta_K^2 \eta_L + 6\sum_{KLM}\sum u_K u_L u_M \eta_K \eta_L \eta_M \tag{18}$$

$$\left(\sum_K u_K\eta_K\right)^4 = \sum_K u_K^4\eta_K^4 + 6\sum_{KL}\sum u_K^2 u_L^2 \eta_K^2 \eta_L^2 + 4\sum_{KL}\sum u_K^3 u_L \eta_K^3 \eta_L$$
$$+ 12\sum_{KLM}\sum u_K u_L u_M^2 \eta_K \eta_L \eta_M^2$$
$$+ 24\sum_{KLMN}\sum u_K u_L u_M u_N \eta_K \eta_L \eta_M \eta_N \tag{19}$$

If, in addition to the assumptions made above with reference to the η_K distribution, we also assume normality, then the third and fourth moments for the $\bar{b}$ distribution follow very easily.

$$\left[\!\left[(\Delta\bar{b})^3 \right]\!\right] = \frac{\left[\!\left[(\sum_K u_K\eta_K)^3 \right]\!\right]}{(\sum_K u_K^2)^3},$$

and utilizing (18) we have

$$\left[\!\left[u_K^3\eta_K^3 \right]\!\right] = 0$$

$$\left[\!\left[u_K^2u_L\eta_K^2\eta_L \right]\!\right] = 0$$

$$\left[\!\left[u_Ku_Lu_M\eta_K\eta_L\eta_M \right]\!\right] = 0,$$

making the third moment equal to zero.

$$\left[\!\left[(\Delta\bar{b})^4 \right]\!\right] = \frac{\left[\!\left[(\sum_K u_K\eta_K)^4 \right]\!\right]}{(\sum_K u_K^2)^4}$$

$$\left[\!\left[u_K^4\eta_K^4 \right]\!\right] = u_K^4(\mu_4)_K = 3u_K^4\sigma^4$$

$$\left[\!\left[u_K^2u_L^2\eta_K^2\eta_L^2 \right]\!\right] = u_K^2u_L^2\sigma^4$$

$$\left[\!\left[u_K^3u_L\eta_K^3\eta_L \right]\!\right] = 0$$

$$\left[\!\left[u_Ku_Lu_M^2\eta_K\eta_L\eta_M^2 \right]\!\right] = 0$$

$$\left[\!\left[u_Ku_Lu_Mu_N\eta_K\eta_L\eta_M\eta_N \right]\!\right] = 0$$

So that, employing equation (19), we have

$$\left[\!\left[(\Delta\bar{b})^4 \right]\!\right] = \frac{3\sigma^4(\sum_K u_K^4 + 2\sum\sum_{K\,L} u_K^2u_L^2)}{(\sum_K u_K^2)^4}$$

$$\beta_2 = \frac{\mu_4}{\mu_2^2} = \frac{3\sigma^4(\sum_K u_K^2)^2}{(\sum_K u_K^2)^4} \cdot \frac{(\sum_K u_K^2)^2}{\sigma^4} = 3,$$

demonstrating that the $\bar{b}$ distribution is normal.

MOMENT EQUATIONS FOR THE DISTRIBUTION OF THE SLOPE CONSTANT[3]

Before proceeding with the second section of this paper we shall need to demonstrate that $\sum_K u_K U_K = 0$. The value of the y ordinate calculated from the equation of the least square line, for $x = x_K$, can be written

$$y = bx_K + \bar{y} - b\bar{x},$$
$$= bu_K + \bar{y}.$$

Subtracting y_K from both sides of the equation, and rearranging,

$$U_K = v_K - bu_K.$$

Multiplying by u_K, and summing for all k values, we have

$$\sum_K u_K U_K = \sum_K u_K v_K - b\sum_K u_K^2 = 0 \text{ (see equation 7)}.$$

Now if we make the assumption that for each value of k the various determinations of the ordinate corresponding to $x = x_K$ vary according to the normal equation about our single observed y_K as a mean, we have

$$[\![\eta_K^2]\!] = \frac{1}{\sqrt{2\pi}\,\sigma_K}\int_{-\infty}^{+\infty}(U_K + y'_K)^2 e^{-\frac{1}{2}\frac{y'^2_K}{\sigma_K^2}}\,dy'_K$$
$$= U_K^2 + 0 + \sigma_K^2,$$

and

$$[\![\eta_K \cdot \eta_L]\!] = \frac{1}{2\pi\sigma_K\sigma_L}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}(U_K + y'_K)(U_L + y'_L)e^{-\frac{1}{2}\left(\frac{y'^2_K}{\sigma_K^2}+\frac{y'^2_L}{\sigma_L^2}\right)}\,dy'_K dy'_L$$
$$= U_K U_L + 0 + 0 + 0$$

so that the equation from the preceding section

$$\sigma_{\bar{\delta}}^2 = \frac{\sum_K u_K^2\,[\![\eta_K^2]\!] + 2\sum_K\sum_L u_K u_L\,[\![\eta_K \cdot \eta_L]\!]}{(\sum_K u_K^2)^2}$$

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[3] The reader who is not familiar with the method of moments may consult Chapter III of Frequency Curves and Correlation by W. Palin Elderton, Third Edition, Cambridge University Press, 1938.

becomes

$$\sigma_{\bar{b}}^2 = \frac{\sum_K u_K^2(U_K^2 + \sigma_K^2) + 2\sum_K\sum_L u_K u_L U_K U_L}{(\sum_K u_K^2)^2}.$$

Since $\sum_K u_K U_K = 0$, this reduces to

$$\sigma_{\bar{b}}^2 = \frac{\sum_K u_K^2 \sigma_K^2}{(\sum_K u_K^2)^2}. \tag{20}$$

The third and fourth moments are calculated as easily as they were in the preceding section

$$[\![(\Delta\bar{b})^3]\!] = \frac{[\![\{ \sum_K u_K(U_K + y'_K) \}^3]\!]}{(\sum_K u_K^2)^3} = \frac{[\![(\sum_K u_K y'_K)^3]\!]}{(\sum_K u_K^2)^3} \tag{21}$$

$$[\![y'_K{}^3]\!] = 0,$$

$$[\![y'_K{}^2 \cdot y'_L]\!] = 0,$$

$$[\![y'_K \cdot y'_L \cdot y'_M]\!] = 0,$$

so that the third moment equals zero.

$$[\![(\Delta\bar{b})^4]\!] = \frac{[\![\{ \sum_K u_K(U_K + y'_K) \}^4]\!]}{(\sum_K u_K^2)^4} = \frac{[\![(\sum_K u_K y'_K)^4]\!]}{(\sum_K u_K^2)^4} \tag{22}$$

$[\![y'_K{}^4]\!] = 3\sigma_K{}^4$ (making use of the relation $\mu_4 = 3\mu_2{}^2$),

$$[\![y'_K{}^2 \cdot y'_L{}^2]\!] = \sigma_K{}^2 \cdot \sigma_L{}^2,$$

$$[\![y'_K \cdot y'_L \cdot y'_M{}^2]\!] = 0,$$

$$[\![y'_K \cdot y'_L{}^3]\!] = 0,$$

$$[\![y'_K \cdot y'_L \cdot y'_M \cdot y'_N]\!] = 0,$$

so that

$$[\![(\Delta\bar{b})^4]\!] = \frac{1}{(\sum_K u_K^2)^4}\left[3\sum_K u_K{}^4 \sigma_K{}^4 + 6\sum_K\sum_L u_K{}^2 u_L{}^2 \sigma_K{}^2 \sigma_L{}^2 \right]$$

$$= \frac{3}{(\sum_K u_K^2)^4}\left[\sum_K u_K{}^2 \sigma_K{}^2 \right]^2.$$

Now

$$\beta_2 = \frac{\mu_4}{\mu_2^2} = \frac{3(\sum_K u_K^2\sigma_K^2)^2}{(\sum_K u_K^2)^4} \cdot \frac{(\sum_K u_K^2)^4}{(\sum_K u_K^2\sigma_K^2)^2} = 3$$

proving that the distribution of slope constants is normal.

SAMPLING TESTS

The data that were utilized for the sampling check were the birth rates per 1,000 population for the state of Alabama, for the years 1933 to 1937 inclusive.

TABLE 1

Alabama birth rate, 1933-37 inclusive

YEAR	BIRTH RATE PER 1000 POPULATION	x	yCAL.	u_x	v_x	u_xv_x	U_x	u_xU_x	U_x^2	σ OF BIRTH RATE
1933	21.4	0	22.02	—2	—.26	+.52	—.62	+1.24	.3844	.08698
1934	22.6	1	21.84	—1	+.94	—.94	+.76	—.76	.5776	.08874
1935	22.0	2	21.66	0	+.34	0	+.34	0	.1156	.08713
1936	21.0	3	21.48	+1	—.66	—.66	—.48	—.48	.2304	.08473
1937	21.3	4	21.30	+2	—.36	—.72	0	0	0	.08486
Total	...	..	....	..	0	—1.80	0	0	1.3080	.....

The equation of the fitted line is $(y = 22.02 - .18x)$. The figures in the last column of Table 1 were obtained by applying the formula $\sqrt{\frac{pq}{n}}$ to the rates of column 2.

If we substitute directly in equation (16) and check the value of $\sigma_{\bar{b}}$ thus obtained by means of a sampling experiment, what we really get by so doing is a check of formula (12). A complete sampling check of Van Uven's formula for the standard error requires, in addition, a separate check of formula (14a).

Substituting in formula (15) we get

$$\sigma^2 = \frac{1.3080}{3} = .436$$

$$\sigma = .66030.$$

In setting up our normal distributions the best approximation that we could get for σ was the value .656595. Consequently, it was the latter that was substituted in (12), giving

$$\sigma_{\bar{b}}^2 = \frac{(.656595)^2}{10} = .0431117$$

$$\sigma_{\bar{b}} = .20763.$$

Five hundred metal rimmed tags were marked with the numbers indicated in the following table.

TABLE 2

Hypothetical normal distribution of birth rates

$M = 22.02016$, $\sigma = 0.656595$

NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY
20.11	1	21.43	27	22.75	22
20.24	1	21.56	31	22.88	17
20.37	2	21.69	35	23.01	13
20.50	3	21.82	38	23.14	9
20.63	4	21.95	40	23.28	7
20.77	7	22.09	40	23.41	4
20.90	9	22.22	38	23.54	3
21.03	13	23.35	35	23.67	2
21.16	17	22.48	31	23.80	1
21.29	22	22.61	27	23.94	1

The mean of the distribution in Table 2 is 22.02016 and the standard error is .656595.

A total of 750 drawings was made, each time returning the tag to the urn and thoroughly reshuffling before the next draw.

The number on each tag drawn was entered into a table, and the column was designated as the ordinates corresponding to $x = 0$. The

entries were numbered 1 to 750 inclusive, in the order in which they had been drawn. Exactly the same procedure was carried out in order to get the 750 ordinates corresponding to $x = 1$, but before making the entry in the table .18 was subtracted from the figure appearing on the face of the tag. From the ordinates corresponding to $x = 2$ the figure .36 was in each case subtracted; .54 from each ordinate at $x = 3$; .72 from each ordinate at $x = 4$. To each one of the 750 sets of five points a straight line was fitted by the method of least squares. The resulting 750 slope constants had a mean value of —.18208, and a standard error of .20709. The mean and the standard error were calculated from the ungrouped data. As we have indicated above Van Uven's formula for the standard error yields the value .20763. The following table represents a grouping of the 750 slope constants.

TABLE 3

Distribution of slope constants from sampling experiment

SLOPE	FREQUENCY	SLOPE	FREQUENCY	SLOPE	FREQUENCY
—.880 to —.831	1	—.430 to —.381	29	+.020 to +.069	35
—.830 to —7.81	1	—.380 to —.331	33	+.070 to +.119	29
—.780 to —.731	4	—.330 to —.281	52	+.120 to +.169	23
—.730 to —.681	1	—.280 to —.231	76	+.170 to +.219	12
—.680 to —.631	9	—.230 to —.181	70	+.220 to +.269	7
—.630 to —.581	18	—.180 to —.131	72	+.270 to +.319	4
—.580 to —.531	15	—.130 to —.081	80	+.320 to +.369	1
—.530 to —.481	19	—.080 to —.031	70	+.370 to +.419	2
—.480 to —.431	30	—.030 to +.019	57	Total	750

For the value of σ we had recourse to formula (15), because it is the only estimate that is available to the curve fitter who has no knowledge of the variation of his individual observed points. But having done so, it becomes necessary to produce a sampling check of formula (14a). Formula (14a) yields

$$\left[\!\left[\sum_K U_K^2\right]\!\right] = 3 \times (.656595)^2 = 1.29335.$$

$\sum_K U_K^2$ was calculated for each of our 750 lines. The mean value, or $\left[\!\left[\sum_K U_K^2\right]\!\right]$, turned out to be 1.30514. As before, the mean was obtained from ungrouped data. Below is given a table of $\sum_K U_K^2$.

TABLE 4

Distribution of $\sum_K U_K^2$ *in experimental sampling*

$\sum_K U_K^2$	FREQUENCY	$\sum_K U_K^2$	FREQUENCY	$\sum_K U_K^2$	FREQUENCY	$\sum_K U_K^2$	FREQUENCY	$\sum_K U_K^2$	FREQUENCY	$\sum_K U_K^2$	FREQUENCY
0–.099	22	1.0–1.099	36	2.0–2.099	13	3.0–3.099	5	4.0–4.099	1	5.0–5.099	1
.1–.199	42	1.1–1.199	31	2.1–2.199	12	3.1–3.199	5	4.1–4.199	3	5.1–5.199	2
.2–.299	34	1.2–1.299	30	2.2–2.299	15	3.2–3.299	1	4.2–4.299	2	5.2–5.299	1
.3–.399	35	1.3–1.399	28	2.3–2.399	19	3.3–3.399	2	4.3–4.399	2	5.3–5.399	1
.4–.499	32	1.4–1.499	21	2.4–2.499	7	3.4–3.499	3	4.4–4.499	1	5.4–5.499	0
.5–.599	47	1.5–1.599	21	2.5–2.599	9	3.5–3.599	2	4.5–4.599	1	5.5–5.599	1
.6–.699	40	1.6–1.699	27	2.6–2.699	9	3.6–3.699	2	4.6–4.699	2	5.6–5.699	2
.7–.799	32	1.7–1.799	22	2.7–2.799	9	3.7–3.799	1	4.7–4.799	1	5.7–5.799	1
.8–.899	41	1.8–1.899	16	2.8–2.899	5	3.8–3.899	0	4.8–4.899	2	6.7–6.799	1
.9–.999	28	1.9–1.999	15	2.9–2.999	5	3.9–3.999	1	4.9–4.999	0	Total	750

The checks furnished for formulae (12) and (14a) show that formula (16) is correct.

In order to check the standard error formula of the second section (equation (20)) we make use of the last column of Table 1. Five separate normal distributions with means of 21.4, 22.6, 22.0, 21.0, and 21.3 were set up. The standard errors to correspond were .085981, .088458, .085981, .084062, and .084062. The latter are our best approximations to the figures in the last column of Table 1. Accordingly, when substituting in equation (20), the latter were used in preference to these in the last column of Table 1. The five frequency distributions are given in Table 5.

There were drawn 750 sets of five points each, and straight lines fitted as before. The mean of the 750 slope constants, whose distribution is given in Table 6, was —.180051 and the standard error. 026248.

Our formula (20) yields the figure .026968. The agreement is not as good as it was for the Van Uven equation, but it is close enough for our purpose.

TABLE 5

Hypothetical normal distributions for each of the five years

$x=0$		$x=1$		$x=2$		$x=3$		$x=4$	
NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY	NUMBER MARKED ON TAG	FREQUENCY
21.15	1	22.35	1	21.75	1	20.75	1	21.05	1
21.17	1	22.37	2	21.77	1	20.77	1	21.07	1
21.19	3	22.39	3	21.79	3	20.79	2	21.09	2
21.21	4	22.41	5	21.81	4	20.81	4	21.11	4
21.23	7	22.43	7	21.83	7	20.83	6	21.13	6
21.25	10	22.45	11	21.85	10	20.85	10	21.15	10
21.27	15	22.47	15	21.87	15	20.87	15	21.17	15
21.29	21	22.49	21	21.89	21	20.89	20	21.19	20
21.31	27	22.51	27	21.91	27	20.91	27	21.21	27
21.33	33	22.53	33	21.93	33	20.93	33	21.23	33
21.35	39	22.55	38	21.95	39	20.95	40	21.25	40
21.37	43	22.57	42	21.97	43	20.97	44	21.27	44
21.39	46	22.59	45	21.99	46	20.99	47	21.29	47
21.41	46	22.61	45	22.01	46	21.01	47	21.31	47
21.43	43	22.63	42	22.03	43	21.03	44	21.33	44
21.45	39	22.65	38	22.05	39	21.05	40	21.35	40
21.47	33	22.67	33	22.07	33	21.07	33	21.37	33
21.49	27	22.69	27	22.09	27	21.09	27	21.39	27
21.51	21	22.71	21	22.11	21	21.11	20	21.41	20
21.53	15	22.73	15	22.13	15	21.13	15	21.43	15
21.55	10	22.75	11	22.15	10	21.15	10	21.45	10
21.57	7	22.77	7	22.17	7	21.17	6	21.47	6
21.59	4	22.79	5	22.19	4	21.19	4	21.49	4
21.61	3	22.81	3	22.21	3	21.21	2	21.51	2
21.63	1	22.83	2	22.23	1	21.23	1	21.53	1
21.65	1	22.85	1	22.25	1	21.25	1	21.55	1
Total	500	Total	500	Total	500	Total	500	Total	500

TABLE 6

Experimental sampling distribution of slope constants

SLOPE	FREQUENCY	SLOPE	FREQUENCY	SLOPE	FREQUENCY
—.095 to —.099	2	—.150 to —.154	41	—.205 to —.209	28
—.100 to —.104	1	—.155 to —.159	23	—.210 to —.214	36
—.105 to —.109	0	—.160 to —.164	54	—.215 to —.219	18
—.110 to —.114	2	—.165 to —.169	41	—.220 to —.224	21
—.115 to —.119	7	—.170 to —.174	73	—.225 to —.229	6
—.120 to —.124	2	—.175 to —.179	35	—.230 to —.234	7
—.125 to —.129	9	—.180 to —.184	66	—.235 to —.239	3
—.130 to —.134	11	—.185 to —.189	58	—.240 to —.244	1
—.135 to —.139	14	—.190 to —.194	54	—.245 to —.249	1
—.140 to —.144	27	—.195 to —.199	33	—.250 to —.254	5
—.145 to —149	13	—.200 to —.204	57	—.270 to —.274	1

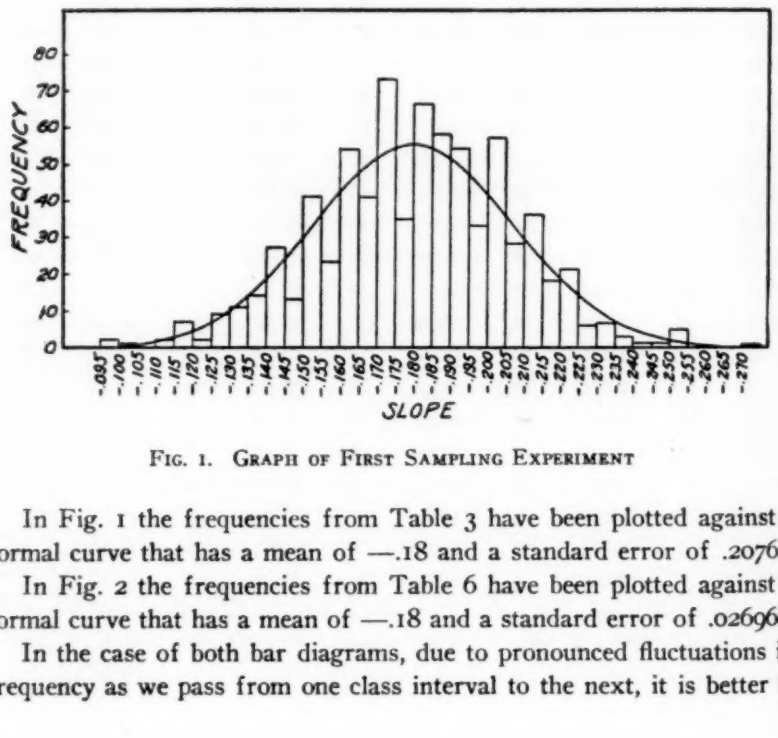

FIG. 1. GRAPH OF FIRST SAMPLING EXPERIMENT

In Fig. 1 the frequencies from Table 3 have been plotted against a normal curve that has a mean of —.18 and a standard error of .20763.

In Fig. 2 the frequencies from Table 6 have been plotted against a normal curve that has a mean of —.18 and a standard error of .026968.

In the case of both bar diagrams, due to pronounced fluctuations in frequency as we pass from one class interval to the next, it is better to

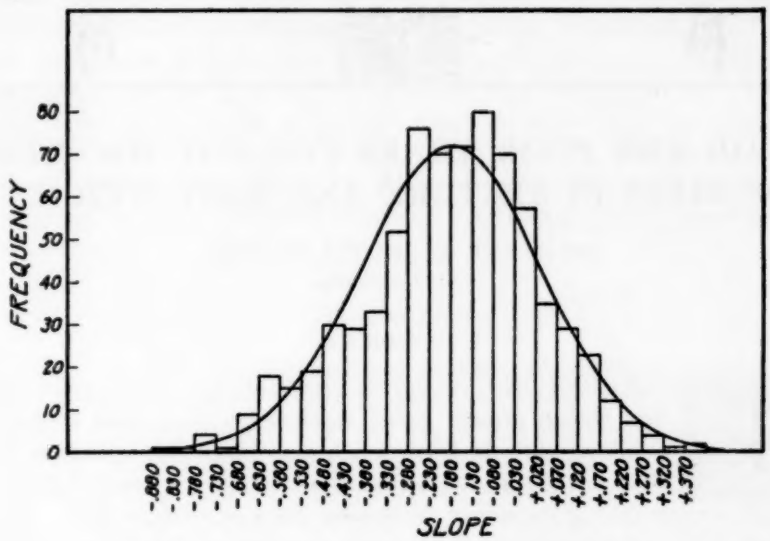

FIG. 2. GRAPH OF SECOND SAMPLING EXPERIMENT

defer judgment as to whether or not the two plotted normal curves adequately describe the data. For Fig. 1 a skew curve would probably give a better fit, but as far as Fig. 2 is concerned a normal curve does as well as any other. If the figures of Table 2 and 5, appearing under the head of *Number marked on tag,* had been arranged in an order with a much smaller class interval, we are disposed to believe that then the greater part of the discrepancy between the bar diagram and its corresponding theoretical normal curve would have disappeared. The reason why a smaller interval was not used is because the notion of calculating the third and fourth moments only occurred to the writer near the close of the investigation when all of the sampling had already been carried out.

SUMMARY

1. When there is no information available as to the variation of each of the individual ordinates, and a straight line is fitted to the data by the method of least squares (vertical residuals), then the standard error of the slope constant resulting from the calculation is obtained by substituting in equation (16).

2. When the variation of each individual ordinate is known equation (20) is to be used.

GOOD AND POOR YEARS FOR THE GROWTH OF GIRLS IN STATURE AND BODY WEIGHT

BY FRANK K. SHUTTLEWORTH
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THE PROBLEM

FETHERSTON [1] in 1887 was probably the first to point out that human growth varies significantly from year to year. Working with the birth weights of Australian infants from 1857 to 1887 he found that these were three hundred grams below average during the severe depression years of 1876 to 1879. The World War and the subsequent economic dislocations stimulated a large literature in the field which has been competently reviewed and summarized by Sanders.[2] The unhappy conditions of the early 1930's led to similar studies of which the most important were a series of papers by Palmer.[3, 4, 5] Palmer found that gains in weight of 1958 elementary school children in Hagerstown, Md., from May 1933 to May 1934 were 8.7 per cent below comparable annual gains of nearly eight thousand children in the same school system during the years 1921 to 1927. This unfavorable growth, however, was not attributed to economic factors because similar deviations from normal growth occurred from year to year during the prosperous times of 1921 to 1927. Thus, from May 1924 to May 1925 gains in weight were 8.5 per cent below normal, while

[1] Fetherston, R. H. Weight of Victorian infants. *Australian Medical Journal* 1887, 9, 495-496.

[2] Sanders, Barkev S. Environment and Growth. *Baltimore.* Warwick and York, 1934. Pp. 375.

[3] Palmer, Carroll E. Variations of growth in weight of elementary-school children, 1921-28. *U. S. Pub. Health Reports,* 1933, 48, 993-1005.

[4] Palmer, Carroll E. Growth and the economic depression. A study of the weight of elementary-school children in 1921-27 and in 1933. *U. S. Pub. Health Reports,* 1933, 48, 1277-1292.

[5] Palmer, Carroll E. Further studies of growth and the economic depression. *U. S. Pub. Health Reports,* 1934, 49, 1453-1469.

from May 1926 to May 1927 they were 5.5 percent above normal. These findings hold for both sexes aged seven to twelve. Palmer wisely offered no explanation of these very interesting findings save the negative one that they could not plausibly be attributed to economic factors. There are, however, a number of specific questions which need to be raised and which are amenable to investigation. First, is this phenomenon local? Second, does it hold for different aspects of growth as stature and body weight? It is with these two questions that the present paper is concerned.

AVAILABLE DATA

The basic data consist of repeated measurements collected by the Harvard Growth Study under the direction of Professor Walter F. Dearborn.[6] We have selected for this study 568 girls from the cities of Medford and Beverly where measurements were made in October, November, and December of each year. On the average, 10.9 sets of annual meaurements are available for these cases. The initial measurements in Medford were made in the fall of 1922 while those in Beverly were made in the fall of 1923. In both cities the children were initially in the first grade of school. Medford children were required by local school regulations to be six years old for entrance to the first grade, while Beverly children were permitted entrance to the first grade as early as age five. In addition the Medford school system, even in the first grade, had a considerable number of scholastically retarded children. It results that measurements in the fall of 1924 give annual increments for children ranging in age from 6.5 (6.25 to 6.74) to 11.5 and it is this wide age range which provides the necessary comparative data for the present study. Thus, we may compute the average growth of girls from age 10.5 to 11.5 separately for each of the six successive years 1923 to 1924, 1924 to 1925, 1925 to 1926, 1926 to 1927, 1927 to 1928, and 1928 to 1929 and determine which of these six years was most favorable for the growth of girls from age 10.5 to 11.5. Similarly, we may compute the average growth of girls from age 10.0 to 11.0 and from age 9.5 to 10.5 for each of five successive years, etc.

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[6] Dearborn, W. F., Rothney, J. W. M., and Shuttleworth, F. K. Data on the Growth of Public School Children (From the Materials of the Harvard Growth Study). *Monog. Soc. Res. Child Develop.*, Vol. III, No. 1. *Washington, D. C.*, National Research Council, 1938. Pp. 136.

PROCEDURE AND RESULTS

While the foregoing suggests the general logic of our procedure, the analysis must also take account of factors other than chronological age which determine a given annual increment. The detailed steps were as follows.[7] First, corrections were applied to all increments involving time intervals between measurements differing from an exact year by .04 years or more. Such corrections were applied to 21.4 per cent of the 11,243 increments of stature and body weight available on our 568 cases. Second, the deviation of each increment from the normal expected increment for sex, chronological age, age at maximum growth in stature, and the timing of measurements relative to age at maximum growth was determined. It is not necessary to explain in full these standards of normal growth since they are presented in detail in another publication.[8] It is sufficient to say that six standards were employed for each dimension, namely, separate standards for girls with ages at maximum growth prior to age 11.75, between 11.75 and 13.24 and after 13.25, and each of these separately for cases having measurements coinciding with and not coinciding with ages at maximum growth. The detail of these standards for the two dimensions will be found in Tables 38, 39, and 40 of the monograph just cited. For example, the normal increments of girls having ages at maximum growth prior to 11.75 and measurements coinciding with age at maximum growth as taken from Table 38 are 6.0, 5.8, 5.8, 6.7, 8.7, 6.4, 3.1, 1.4, .7, .3, .2, .2 and zero centimeters from 4.0 years prior to 8.0 years after age at maximum growth. The standards were taken to only the nearest first decimal to facilitate computation of deviations from the original increments which involve one decimal. Third, the average deviations from normal annual gains have been corrected to the third decimal of centimeters and kilograms. Thus, the average deviation from normal annual gains of girls from age 10.5 to 11.5 in each of the six successive years noted above are .500, —.219, —.028, .034, .084, and —.331 centimeters for 3, 26, 87, 82, 61, and 29 cases respectively. If our standards were exact, the weighted average for these 288 cases should be zero. Actually, the weighted average is —.029; hence, the true deviations normal growth are .529,

[7] Acknowledgments are due to the Works Progress Administration of Connecticut, Project 465-15-3-12, for clerical and statistical assistance.

[8] Shuttleworth, Frank K. The Physical and Mental Growth of Girls and Boys Age Six to Nineteen in Relation to Age at Maximum Growth. *Monog. Soc. Res. Child Develop.* Vol. IV, No. 3, 1939. Pp. 291.

TABLE 1

Average deviations from normal annual gains in stature and body weight of girls by age groups for each year from the fall of 1924 to the fall of 1933

INTERVALS: FALL OF	MEAN INTERVAL YEARS (1)	TOTAL NO. CASES (2)	STATURE (*centimeters*) Age* 6.5 to 7.5 (3)	Age* 8.0 to 9.5 (4)	Age* 9.5 to 11.5 (5)	Total Cases Original (6)	Total Cases Corrected (7)	BODY WEIGHT (*kilograms*) Age* 6.5 to 7.5 (8)	Age* 8.0 to 9.5 (9)	Age* 9.5 to 11.5 (10)	Total Cases Original (11)	Total Cases Corrected (12)
1923 to 1924	1.0058	532	.279	.251	.392	.299	.266	—.028	—.004	—.253	—.083	—.095
1924 to 1925	.9979	568	—.168	—.285	—.184	—.244	—.212	.065	.144	—.001	.080	.086
1925 to 1926	1.0017	568	—.052	—.005	.040	—.004	—.014	—.034	—.046	—.119	—.064	—.070
1926 to 1927	1.0037	568	.071	—.044	—.167	—.050	—.072	.010	.112	.076	.074	.058
1927 to 1928	.9977	568	.125	.186	.256	.191	.204	.047	—.424	—.164	—.222	—.211
1928 to 1929	.9986	567	—.073	—.180	—.200	—.157	—.150	.431	.311	.143	.294	.300
1929 to 1930	1.0009	556	—.027	.124	.135	.086	.083	.084	—.187	—.032	—.069	—.072
1930 to 1931	1.0149	526	—.038	—.161	—.015	—.087	—.116	—.112	—.001	.077	—.012	—.050
1931 to 1932	.9920	487	.080	.105	.019	.077	.085	.072	—.001	.069	.038	.051
1932 to 1933	.9987	365	—.059	.044	.004	—.042	—.041	.101	—.071	.046	.010	.011

* Age in the fall of 1924.

—.190, .001, .063, .113, and —.302 centimeters. It will be noted that the interval from the fall of 1923 to the fall of 1924 appears to be particularly favorable for the growth of girls from age 10.5 to 11.5 since they gained more than half a centimeter in excess of normal. However, only three cases are involved. Hence, our fourth step is to examine the 1923 to 1924 growth records concerning other age groups. Such data are available for eleven groups of girls who were age 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, and 11.5 in the fall of 1924, the groups consisting of 29, 61, 61, 84, 82, 82, 87, 47, 26, 6, and 3 cases respectively, or a total of 568 cases. However, deviation increments for the year ending in 1924 are available for only 532 cases. The average deviations from normal annual gains of these groups are .053, .169, .506, .057, .294, .419, .365, .508, .275, .273, and .529 centimeters respectively. Considering the small number of cases in some of the groups, these are remarkably consistent results indicating that the interval from the fall of 1923 to the fall of 1924 was uniformily favorable to growth in stature for all age groups of girls from 6.5 to 11.5. For the purpose of summary report in Table 1 we have combined the findings for the first three, for the next three, for the last five of the above groups, and for all groups obtaining average deviations from normal average gains in stature of .279, .251, .392, and .299 centimeters as reported under columns (3), (4), (5) and (6) for 142, 236, 154, and 532 cases, age 6.5 to 7.5, age 8.0 to 9.0, age 9.5 to 11.5, and age 6.5 to 11.5 respectively in 1924. The standard deviation of the 532 deviations from normal gain is 1.617 centimeters giving a probable error of .024 centimeters. Similarly, the average deviations from normal gain of —.244, .191, and —.157 centimeters for the year ending in 1925, 1928, and 1929 have probable errors of .021, .026, and .029 centimeters respectively and represent clearly significant deviations from normal. Data for 1922 to 1923 and for 1933 to 1934 are not reported because data for the first interval are limited to Medford cases while those for the second of these intervals are limited to Beverly cases. We have carried the analysis of stature one step further in column (7) in order to correct for the slight differences in the exact intervals between measurements. Thus, the interval 1923 to 1924 is .0058 years in excess of an exact year; hence, the average deviation of .299 centimeters in column (6) is too large. From other data we compute the average gross increment from 1923 to 1924 of the available cases to be 5.77 centimeters or an in-

dicated correction for the long interval of .033 centimeters giving the corrected average deviation of .266 centimeters in column (7). These final figures indicate that 1924 (fall of 1923 to fall of 1924) was a very good year for growth in stature, 1925 was a very poor year, 1926 was almost normal, 1927 was not so good, 1928 was very good, 1929 was very poor, 1930 was good, 1931 poor, 1932 good, and 1933 very slightly below normal. Comparable data for body weight, involving the same cases, are reported in columns (8) to (12). Only the deviations of —.211 and .300 kilograms for 1928 and 1929, having probable errors of .054 and .063 kilograms respectively, seem to deviate significantly from normal. Of interest is the fact that 1928 was a good year for stature and bad for weight, while 1929 was bad for stature and good for weight. A similar negative relationship seems to hold in 1924 and 1925. The correlation between the figures of columns (7) and (12) is —.69 ±.11 tending to confirm the suggestion that good years for stature are apt to be bad years for weight. We are unable to detect any agreement between our findings for weight and Palmer's findings, but there are only six comparable years and his measurements were made in May while ours were made largely in October and November.

SUMMARY

This study employs measurements of stature and body weight on 568 girls repeated at annual intervals from the fall of 1922 to 1935 by the Harvard Growth Study. The annual increments of these cases have been expressed as deviations from a rather precisely determined normal expectancy. These deviations have been analyzed for each of eleven initial age groups and for each of ten years. The year 1924 (fall of 1923 to fall of 1924) showed gains in stature averaging .266 centimeters above normal, while 1925, 1928 and 1929 showed gains averaging .212 centimeters below, .204 centimeters above, and .150 centimeters below normal respectively. Gains in weight were .211 kilograms below normal in 1928 and .300 kilograms above normal in 1929. All of these differences are statistically reliable. There is a tendency especially in 1924, 1925, 1928, and 1929 for above normal gains in stature to be accompanied by below normal gains in weight, and vice versa. These findings have been compared with similar data of Palmer, but the two sets of

findings are not sufficiently comparable to indicate whether such deviations from normal gains represent a general or local phenomenon. While the deviations from normal gain are small in any year, it is clear that the cumulative influence of a long series of good or of poor growing years might have a profound effect on mature stature and weight.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U.S.A.

I. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

ALLEE, W. C., and THOMAS PARK. Concerning ecological principles. *Science*, Vol. 89, pp. 166-169, 1939.

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